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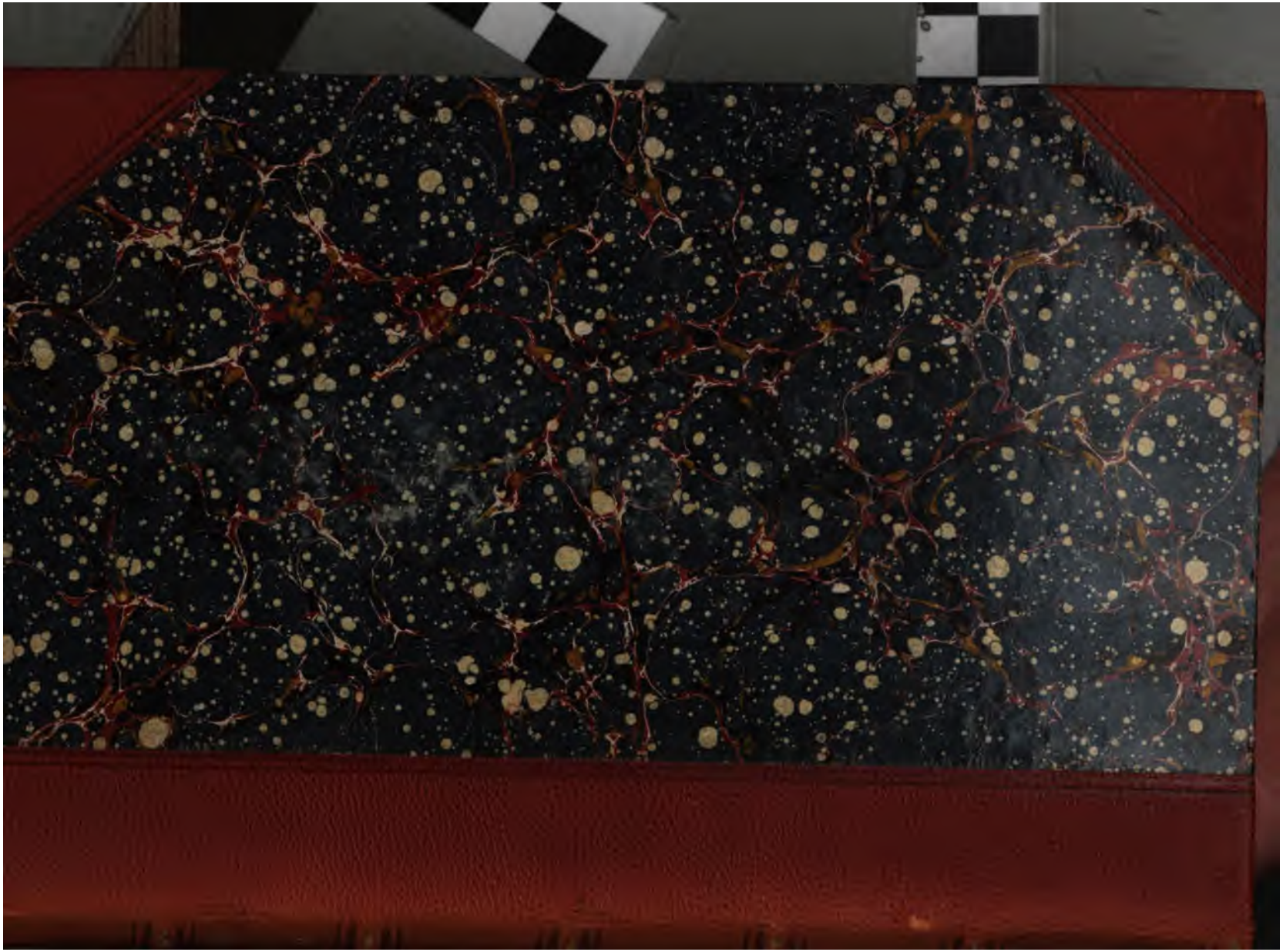

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TRANSACTIONS

OF

THE MANCHESTER

GEOLOGICAL SOCIETY.

VOL. III.

LONDON:
SIMPKIN, MARSHALL AND CO.:
AND "THE MINING JOURNAL" OFFICE, 26, FLEET STREET.
MANCHESTER:
THOMSON AND BAXTER, 10, PRINCESS STREET.

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ADVERTISEMENT.

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The Council of the Manchester Geological Society make it known to the Public that the Authors and Speakers alone are responsible for the facts, reasonings, and opinions given in the respective Papers and Discussions in this volume.

ERRATA.

—o—

[Many of the following Errata have been noticed in numbers issued subsequently to those in which they occurred. They are again inserted here for convenience of correction in the completed volume.]

Page 6, line 5, for "David Forbes, Esq.," *read* "John Edward Forbes, Esq."

„ 17, „ 29, „ "of coal in our pits," *read* "in the Cornish mines."

„ 144, „ 6, „ "whom," *read* "who."

„ 175, „ 17, „ "proportional," *read* "inversely proportional."

„ 228, „ 2, „ "eight," *read* "eight and a half,"

„ 228, „ 27, „ "71·726," *read* "78·726."

„ 230, „ 4, „ "New Cottle," *read* "Newbottle."

„ 234, „ 28, „ "no two," *read* "no other."

„ 245, „ 8, „ "to scientific," *read* "too scientific."

„ 262, „ 15, „ "$v^2 = \sqrt{\cdot 0018}$," *read* "$v = \sqrt{\cdot 0018}$."

„ 263, „ 32, „ "motion," *read* "notion,"

„ 274, „ 20, after "circulating," *insert a comma,*

„ 227, „ 31, „ "gases," *insert a comma,*

„ 281, „ 19, for "there is doubt," *read* "there is no doubt."

„ 290 „ 10, „ "$h = \frac{k l v^2}{d g^2}$" *read* "$h = \frac{k l v^2}{2 d g}$,,

„ 303 „ 14, „ "common," *read* "at Common."

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 1.] [Session 1860-61.

The TWENTY-SECOND ANNUAL MEETING, *held October 25th*, 1860.

Joseph Dickinson, Esq., F.G.S., in the Chair.

The following Report of the Honorary Curators was read :—

CURATORS' REPORT.

During the past year nothing whatever has been done with the specimens at the Museum, as the Curators have had no access to the cases, owing to the causes stated in their report of last year. The office of Curator is perfectly useless unless the Council enforce the rights of the Society, and obtain for their officers the fair and just carrying out of the arrangement entered into between the Geological and Natural History Societies, which stipulates "that the management of the united collections shall be vested in two Curators of this Society, in connection with two Curators of the Natural History Society."

The following donations have been made to the Society during the past year :—

Cast of a large flint instrument; two flint instruments from Amiens and St. Acheul, and five so called beads and a plaster cast of a large flint axe-head from the drift deposits of the north of France, by Joseph Prestwich, Esq., F.R.S., F.G.S.

Specimens from the *Pleistocene* marine beds of Uddevalla, Sweden, viz.:—*Balanus Hameri; B. porcatus; B. crenatus; Buccinum undatun; Trophon scalariforme; Pecten Islandicus; Mytilus edulis; Astarte arctica; A. elliptica; Mya truncata; Saxicava rugosa*: from the

marine beds, (raised beach,) St. Andrew's, comprising *Littorina littorea*; *L. littoralis*; *Trochus cinerarius*; *Patella vulgata*; *P. lævis*; *Nassa pygmæa*, & *Spirorbis*: from the brick earth of Ilford, Essex, *Molar of Elephas primigenius*; *Bones of Bison priscus*; also *Helix nemoralis*; *Cyrena consobrina*:—presented by R. D. Darbishire, Esq., B.A.

Crystals of Selenite found in Mr. Shaw's Colliery, Haughton,—by Joseph Dickinson, Esq., F.G.S.

A steel mill used in collieries before the invention of safety lamps,—F. C. Clark, Esq., of Garswood.

Teeth of *Rhizodus Hibberti* and *Melgalichthys Hibberti* from the roof of the Field Mine, Glodwick,—presented by Mr. Wilde.

A paper on the Keuper Beds of Wirrall, by G. H. Morton, Esq., president of the Liverpool Geological Society,—presented by the author.

The following Reports of the Council and of the Treasurer were then read:—

Report of the Council.

In accordance with the rules of the Society, the Council have to present to the members a report of their proceedings for their past year of office, accompanied by a statement of the receipts and disbursements connected with the business of the Society.

During the last year, eighteen new members have joined the Society; one has died, and one resigned, owing to removal to a distance. Considerable interest has been shewn in the proceedings of the Society so far as the attendance of members is concerned, but still the great bulk of the Society contribute their subscriptions for its support, rather than take any active interest in the meetings. For the convenience of country members the meetings have been held on Tuesday, and during the busiest part of the day. This has

prevented many of the members of the Society, resident in Manchester, from attending the meetings, which would be far more convenient for them if held in the evening; but on the whole, it must be admitted, that country members form the majority of the Society.

Two excursions have been made by the members, namely,—one to Gawthorpe Hall, on an invitation of our President, and the other to Brooksbottom and Walmersly, on the invitation of John Hall, Esq., of Nangreaves. In both much valuable information was afforded to the members who joined the excursions, and a hearty and hospitable reception was given, which all who had the pleasure of partaking of these entertainments will long remember. It is to be hoped that similar excursions will be afforded to the members during the present session.

During the past year a considerable addition has been made to the Library, and a catalogue of the Books has been printed and circulated amongst the members.

The transactions of the Society have been published in parts, every month, and a copy sent to each member. It is desirable that in publishing the transactions in future, one of the Council should act as editor, and the proof sheets should be submitted to the authors before their papers are printed. This will prevent the repetition of certain mistakes which appear in the proceedings of the past year.

The Council regret that during the past year nothing has been done by the Natural History Society towards carrying out, fairly and fully, the spirit of the agreement under which the two Societies came together. Your Council have done all in their power to leave the differences to the decision of a disinterested party; but the Council of the Natural History Society have hitherto declined to accede to so equitable a proposal.

MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET,—1859-60.

Abstract of Receipts.

1859.		£.	s.	d.	£.	s.	d.
Sep. 30.	Balance brought down				231	17	11
	Subscriptions, 1859-60, 83...	83	0	0			
	„ Half-year, 1859-60, 10...	5	0	0			
	„ 1858-9, 4 ...	4	0	0			
	„ 1857-8, 2 ...	2	0	0			
	„ 1856-7, 2 ...	2	0	0			
	„ Half-year, 1855-6, 1 ...	0	10	0			
					96	10	0
	One Life Composition—T. R. Coulthart, Esq.				10	0	0
	Interest allowed by the Bankers.....				3	10	7
	Memoirs sold				0	15	0
					£342	13	6

E. E. HENRY M. ORMEROD, Treasurer.

Abstract of Payments.

1859.		£.	s.	d.	£.	s.	d.
October.	Balance repaid Treasurer ...				9	12	8
	Library.....				12	7	10
	Reports of Meetings, List of Members, &c.....				59	12	0
	Printing and Stationery.....				5	4	0
	Advertising				3	17	3
	Postages and delivery of Circulars				12	4	4
	Collector's Commission				4	15	6
	Miscellaneous				1	8	0
					109	1	7
1860, Sep. 30,	Balance in the Bank.....	228	6	6			
	„ Treasurer's hands	5	5	5			
					233	11	11
					£342	13	6

Examined, and found correct,
Manchester, 16th October, 1860.

JAMES HERTZ, Auditor.

It was moved by Isaiah Booth, Esq., and seconded by T. Farrimond, Esq., and resolved :—

"That the Reports and Balance Sheet now read be entered on the minutes, and printed for circulation."

It was moved by E. H. Birkenhead, Esq., and seconded by John Taylor, Esq., Jun., and resolved :—

"That the thanks of this meeting be given to the Donors of the Society during the past year."

It was moved by T. Farrimond, Esq., and seconded by J. Atkinson, Esq , and resolved :—

"That the thanks of the meeting be given to Sir J. P. Kay-Shuttleworth, Bart., F.G.S., for his services as President during the past year."

It was moved by Isaiah Booth, Esq., and seconded by John Taylor, Esq., Jun., and resolved :—

"That the following Gentlemen be elected office bearers for the ensuing year."

President :

SIR J. P. KAY-SHUTTLEWORTH, BART., F.G.S.

Vice-Presidents :

WILLIAM PEACE, ESQ., F.G.S.
E. W. BINNEY, ESQ., F.R.S., F.G.S.
JOSEPH DICKINSON, ESQ., F.G.S.
R. D. DARBISHIRE, ESQ., B.A.

Treasurer :

H. M. ORMEROD, ESQ.

Auditors :

R. P. GREG, ESQ., F.G.S. | JAMES HERTZ, ESQ.

Honorary Secretaries :

ANDREW KNOWLES, ESQ. | JOHN ATKINSON, ESQ.

Honorary Curators:

E. W. BINNEY, ESQ., F.R.S., F.G.S. | H. M. ORMEROD, ESQ.

Council:

F. SMITH, Esq., M.A. F.G.S.,	JOHN HEELIS, Esq.
THOS. FARRIMOND, Esq.	DAVID FORBES, Esq
THOMAS LIVESEY, Esq.	WM. BLACKBURN, Esq.
ALFRED HEWLETT, Esq.	GEORGE GILROY, Esq.
PETER HIGSON, Esq.	Rev. G. PERKINS, M.A.
T. A. READWIN, Esq., F.G.S.	WM. ROBY BARR, Esq.

And E. W. Binney, Esq., and Wm. Harvey, Esq., Representatives of the Society at the Council Meetings of the Natural History Society.

In consequence of a statement made by R. D. Darbishire, Esq., in reference to the difference between this Society and the Natural History Society, alluded to in the preceding reports, it was moved by John Taylor, Esq., Jun., seconded by E. H. Birkenhead, Esq., and resolved :—

" That the Secretaries of this Society be requested to summon the Curators of the Geological Collection, to arrange the difference between the Societies in regard to the keys of the cases, as this difference appears to have arisen from a misunderstanding on the part of the Council of the Natural History Society."

It was moved by Isaiah Booth, Esq., seconded by John Atkinson, Esq., and resolved unanimously :—

"That the thanks of the meeting be given to Joseph Dickinson, Esq., for his services in the chair on this occasion."

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 2.] [Session 1860-61.

ORDINARY MEETING, NOVEMBER 20th, 1860.

SIR J. P. KAY-SHUTTLEWORTH, BART., in the Chair.

The following gentlemen were announced as having been elected Ordinary Members of the Society :—

R. A. ESKRIGGE, ESQ., Old Hall Street, Liverpool;
JOHN EVANS, ESQ., Edge Lane, Royton;
DAVID GREENHALGH, ESQ., Stubbins, near Ramsbottom;
SAMUEL WILD, ESQ., Dean House, Buersill, Rochdale;
JAMES WILD, ESQ., Dean House, Buersill, Rochdale;

The following donations of books were announced :—"The Franzensquelle in Eger-Franzensbad," by DR. P. CARTELLIERI, and "The Kammerbühl, a Volcano in Franzensbad," by DR. A. A. PALLIARDI :—from JAMES HERTZ, ESQ.

"The Proceedings of the Geologists' Association, No. 5":—from the REV. L. H. MORDAQUE, M.A.

"Memoirs of the Geological Survey of Great Britain, &c."—the following parts, viz. :—"The Geology of the Country around Wigan," and "The Geology of the Country around Prescot, Lancashire," both by EDWARD HULL, ESQ., B.A., F.G.S. :—from the Author.

Mr. John Taylor, Jun., made a communication respecting a Petrifying Spring, which deposited Travertine at the foot of Kinder

Scout, Derbyshire, and came out of the Millstone Grit there, and which he had described at length in the "Geologist," of the present month of November.

Mr. Binney exhibited a large Crystal of Selenite, three inches in length, found in the "till" of drift clay in North Cheshire, between Egremont and Birkenhead. It was picked out of the face of the cliff, and, not being water-worn, it had evidently been formed since the clay had been drifted into its present position. Several instances, he said, were on record of similar crystals having been formed in a comparatively short period of time. He mentioned one in which the clay from the Tunnel through Primrose Hill, on the London and North Western Railway, contained no crystals when first dug out, but, in a very short time after, it was found to be filled with them. They appeared to have shot through the mass in every direction in the course of a few days.

Mr. W. Roby Barr stated that he had recently seen Gypsum in the "till" between Egremont and Seacombe.

Mr. Binney remarked that these facts showed that the drift clay often contained a considerable quantity of sulphate of lime diffused through its mass. Altogether the drift deposits throughout the country required to be more attended to. A great amount of important information, he was convinced, would be derived from a patient, careful and minute examination of the drift in different localities. Too little attention had hitherto been bestowed upon deposits of this kind, which might, he thought, if properly examined, afford traces of the works of man in this country, at an earlier period of the earth's history than he had generally been supposed to exist in these regions. The flint implements found in the drift near Amiens showed, in some measure, the kind of discoveries that might be expected. Indeed we could hardly tell yet what our careful researches in this much neglected deposit might reveal to us. What we want is that each member of our Society should carefully examine the drift in his own neighbourhood. Sections should be got whenever it was practicable to obtain them. If a mill-pond was being dug, a cutting made, or a pit or a well sunk, the Geologist

should avail himself of the opportunity to collect all the facts he could. By each member pursuing this plan in his own neighbourhood, a mass of highly important facts would be collected, which might ere long throw an entirely new light upon this hitherto comparatively obscure department of Geology.

The President said it was very desirable that a brief manual should be printed and put into the hands of young and energetic Geologists of our district, pointing out the kind of facts they ought to record, and the sort of phenomena they should take cognizance of. Such a guide book would be of great value; for there were several young men in his neighbourhood, who, he was sure, would make a good use of it, and who would soon amass a valuable collection of facts, did they but understand upon what principle their enquiries were to be conducted.

Mr. E. W. Binney, F.R.S., F.G.S., then read a paper, illustrated by a map and sections, entitled "Observations on Down Holland Moss."

[By way of preface he said, the main facts of this communication had been laid before this Society seventeen years ago; but as the paper was little known, and the facts it contained were of an interesting nature, as tending to explain how coal beds might be formed, and to show, among other things, the manner in which a single seam, as is often the case in the coal formation, is split up or divided into two or more seams, he thought this second edition of it would not be unacceptable, or without its use to many of the present members of the Society.]

Down Holland is situated to the west of Ormskirk, about midway between that town and Formby, which lies on the sea coast. The underlying rock in this district is the new red sandstone; the dip of which varies from N.W. to S.W. in the neighbourhood of Ormskirk, Down Holland, and Halsall. At the two last-named places the rock is succeeded on its dip by deposits of peat, which occupy the low lands in the western portions of these townships,

and extend through Formby to the sand hills adjoining the sea. In the upper or eastern part of Down Holland Moss this peat is of the common black kind, very much decomposed, and showing very little vegetable structure. Its thickness is from two to three feet. Under it is a bed of white sand, varying from an inch to two feet in thickness, and resting on a blue or brown clay, resembling the common till. Trunks of trees, such as oak, pine, and willow, lie prostrate in the peat, near to their stools, which are seen *in situ* standing upright in the sand and clay where they grew. These trunks are so numerous as to exhibit the appearance of forest prostrated by the action of the wind or the hand of man. In proceeding to the west and north of Down Holland township, to the brook which divides it from Formby, the peat gradually thickens. Near the junction of the Barton Brook with the Fleam Brook is a tract of peat land, about 100 statute acres, the greatest portion of it in Down Holland, but some of it extending across the brook into Formby, which affords a fluid bituminous matter, which, on being examined, has been found to be petroleum. Peat saturated with this, when dry, burns with a bright white flame, and is known among the farmers of that district by the name of "light turf," from the circumstance of its being used by the country people in lighting their fires.

The greater portion of the moss lies at a lower level than the high water mark of the sea at Formby. The whole of it has been under cultivation for fifty or sixty years. The peat, to the west, disappears under a covering of drift sand, brought by the winds from the sand-hills near the beach.

In walking over the land where the peat contains petroleum, its presence was indicated by an empyreumatic smell, and the water in the ditches was coated with a thin film of an oily iridescent fluid (petroleum) which floated upon its surface. Immediately under the black decomposed peat forming the soil in some stubble fields, was found a hard black pitchy layer, of three or four inches in thickness, the material of which yields no smell unless it is burnt. On being exposed to the atmosphere for some time the

pitchy matter lost much of its inflamability, and was ultimately converted into black mould. This substance occurred also under the roots of the grass in old sward fields, but it there yielded an odour similar to that given off by the petroleum that floated upon the surface of the water, and pervaded the moist peat. In order to ascertain the thickness of the deposit of peat, a hole was made in a grass field with a six-inch boring instrument, when the following beds, in descending order, were found :—*

	Yds.	Ft.	In.
1. Black decomposed peat, with scarcely any vegetable structure; the lower part hard, and of a pitchy nature	0	0	8
2. Black peat, very moist, full of petroleum, and showing few traces of vegetable structure, except in the lower parts of it, which contained compressed reeds, &c.	1	0	10
3. Soft blue silty clay	1	0	6
4. Dry, mouldy peat, containing seeds resembling mustard seed. [The lower part of this bed, like No. 2, was reedy, but devoid of empyreumatic smell.]	1	1	0
5. Blue silty clay	0	0	6
6. Blue sandy clay,—depth penetrated	1	0	6
Total	5	1	0

This bore hole being left open and examined three weeks afterwards, was found to be filled with water to within two inches of the top. Upon the surface of this water was a thin film of a yellowish oily matter, having a most offensive smell, similar to that emitted by a mixture of sulphuretted hydrogen and ammoniacal gases. This occurred on the surface only; for immediately below it was found the petroleum, yielding an empyreumatic odour as before mentioned. Several holes were made to ascertain the thickness of the upper bed of peat, which was found to increase towards the west and north-west. *The parting of silty clay gradually thinned, and finally disappeared towards the north and east.*

The upper bed of peat, and its underlying stratum of silty clay, was found to continue across several fields to the west from the above hole without any variation, the peat being full of the

* I am indebted to J. H. Talbot, Esq., of Wrightington, for being at the trouble of making these bores, and for a considerable portion of the information contained in this paper.

iridescent oily fluid. It then begins to be overlaid by a deposit of fine light coloured sand, resembling that composing the sand-hills near the beach at Formby, and evidently brought thence by the winds. This bed of sand, at first thin, soon increases to a yard in thickness, and no doubt gradually increases under the village of Formby, all the way to the sea. Some of the men employed in boring, stated that the beds of peat and clay were at times visible under the sand, at ebb tide, on the beach of Formby,—a statement which was confirmed by Professor Harkness, F.R.S.

On the Origin of the beds of Silty Clay and Peat, and their resemblance to certain of the Carboniferous Strata.

The present position of the two beds of peat, the parting of silty clay between them, and the circumstance of their being partially covered up by a deposit of sand, are all subjects of interest. The greater part of Down Holland and Halsall, and the whole of Altcar and Formby are based upon a deposit of till, which probably rests upon the upper new red sandstone formation, though this rock is seldom seen, except in the upper part of the district. On the top of the hill, a thin bed of whitish sand, about 14 or 16 inches thick, frequently occurs. In the eastern parts of Halsall and Down Holland, this sand generally forms the substratum upon which the peat reposes; but in the southern and western parts of those places, as well as at Formby, the peat rests upon a silty clay occurring above the sand. The lower bed of silty clay effervesces strongly when treated with sulphuric acid. From its composition scarcely a doubt can exist but that it was deposited by the waters of the sea that formerly flowed from the south, near the bed of the present river Alt, over the greater portion of Formby and Altcar, and the lower part of Down Holland. Owing to the shifting of the sands in the adjoining sea, and the consequent changing of the channel of the Alt into the estuary of the Mersey, a sand bank was thrown up, which not only prevented the sea from flowing along its accustomed course upon the low lands of the townships just named, but also pent up the waters on the land side, and prevented the

drainage of the whole tract of ground adjoining the Barton and Fleam Brooks and the river Alt, and thus caused a morass which produced the lower bed of peat.

Upon the shifting of the barrier of sand next the sea, the waters again flowed over the lower and western part of the morass last described, leaving the parting of silty clay. This last deposit, when treated with acid, effervesces briskly, and in other respects resembles the upper bed. After a time, a second bank of sand, similar to the one first named, was thrown up, which stopped the ingress of the sea and the egress of the fresh water, so as to cause a second morass, which produced the second bed of peat. Should the artificial drainage of this district be at any time neglected, there is every probability that it would be again converted into a morass.

These beds of peat and their associated strata of silty clay, in their thickening and thinning, afford us considerable information as to the mode in which many of the coal seams in Lancashire and other localities were formed, and explain to us the origin of the partings which frequently occur, as well as show us that the vegetable matter now forming coal, might have grown, and in all probability did grow, on the very places where that mineral is found, and was not drifted there by the action of water. Difference of thickness in the same seam, and instances of a single seam being sometimes divided by a parting of clay, so as to become two, are facts that have been adduced as strong objections to the hypothesis that "*the material of which coal is composed grew on the spot where the coal itself is found.*" Instead, however, of these facts being incompatible with the hypothesis just mentioned, they afford a strong, if not an unanswerable argument in favour of its correctness. The thinning out of the upper bed of silty clay between the two strata of peat, so as to allow the latter to unite, is an exact resemblance of what is seen in the parting of fire-clay, in the four-feet mine at Pendleton. In that mine there are two seams of coal, the one four feet and the other ten inches in thickness, with a parting of three

feet of clay between them. In one of the adjoining mines, 400 yards to the north-west, this parting of clay is seen gradually to diminish till the two seams of coal run together, forming one bed of five feet two inches in thickness. Similar instances might be adduced from almost any coal-field. On the banks of the Alt, the lower bed of peat, situated between the two strata of silty clay, is seen to diminish gradually in thickness, and finally to vanish towards the south, allowing the two deposits of silty clay to unite into one,—thus affording an exact resemblance of what is so often seen to take place in the true coal measures.

On the Composition and Origin of the Petroleum.

Although it is not uncommon to find traces of an oily matter floating upon the surface of the water that drains out of peat bogs in the low mosses of Lincolnshire and other parts of England, no instance was known, at the time when the facts here detailed were collected, of the occurrence of peat so strongly impregnated with petroleum as that found at Down Holland. Petroleum, or "rock-oil," is found in various parts of the world,—in the Birman empire, on the banks of the Irawaddi, are powerful springs of it; it is abundant in Persia; it occurs in Barbadoes; at Tegernsee, in Bavaria; in Auvergne, near Claremont; in Switzerland, near Neuchatel; at Amiano, in Italy; and in Sicily; and near the volcanic isles of Cape de Verde the sea is sometimes covered with it. It is usually of a dark yellowish brown colour, more or less liquid as the temperature is higher. It consists of a combination of carbon and hydrogen, and from it naptha and paraffin are sometimes obtained. Soon after the nature of the Down Holland peat was noticed, the author entertained the idea of manufacturing an oil containing paraffin from it, and though that substance could be obtained, it could not be got in sufficient abundance to pay the cost of procuring it, hence the intention of using it for that purpose was abandoned.

A specimen of the pitchy peat, possessing an empyreumatic smell, found about six inches beneath the surface in an old sward

field in Formby, was analysed by the late Professor John Eddowes Bowman, of King's College, London, and 100 parts were found to contain—

Carbon	60·31
Hydrogen	8·86
Oxygen	30·83
	100

Common peat, according to Regnault, contains—

Carbon	60·89
Hydrogen	6 21
Oxygen	32·90
	100

On comparing these, it is seen that the former—the pitchy peat—has lost ·58 of carbon and 2·07 of oxygen, and gained 2·65 of hydrogen.

In a specimen of dark empyreumatic oil (petroleum) skimmed from the surface of a stagnant pool of water drained from the upper bed of peat, where that deposit is covered by a bed of about 15 inches of drift sand, Professor Bowman found C_{73} united to H_{69}. If this is compared with woody fibre, we have as follows :—

	C.	H.	O.
Woody fibre	160	128	128
Petroleum	73	69	0
Loss	87	59	128

The pitchy deposit found under the surface in the ploughed fields possessed little or no smell, the volatile oil affording it having no doubt evaporated. The specific gravity of this pitchy matter was greater than that of the petroleum, probably from its having lost some of the lighter constituents of that oil, and also from its having combined with a considerable amount of oxygen.

The next point was to ascertain the source whence the petroleum in this locality was derived. At first it was imagined that it might have its origin from some spring which flowed up through the moss from a fissure in the strata underneath. But after the underlying silty clay, sand and till were found to give no trace of any

such oil-spring, and after the *lower* bed of peat was found to be not only destitute of petroleum, but *quite dry*, the inevitable conclusion was arrived at that the oil could not have come from below. An oil-spring rising out of the higher land of Down Holland, or Halsall, and flowing down into the moss was then thought of; but the peat on the eastern side of the moss, although moist, and nearest to such a spring, if it existed, was totally destitute of petroleum. Hence the hypothesis that the petroleum was derived from a spring seemed altogether untenable.

One peculiar feature connected with the upper bed of peat next arrested the attention; it was this:—The western portion of it was covered up with sand; and, according to information derived from Professor Harkness, probably subject sometimes to an infiltration of sea water. These circumstances, added to the fact of the petroleum being found most plentifully at the edge of the sand, led to the conclusion that it is produced by the decomposition of the upper bed of peat, where it is overlaid by the sand.

The chemical process by which the oil has been produced from such materials in such a situation will be more likely to be properly explained by the Chemist than by the Geologist; all that need be said here is that the petroleum is probably the result of a slow fermentation or combustion of the vegetable matter composing the peat, and has been produced in a manner somewhat analagous to the hydro-carbons obtained by the destructive distillation of wood in close vessels.*

Specimens of the pitchy peat and of the silty clay, mentioned in the paper, were laid upon the table.

In reference to the question whence the petroleum mentioned in the paper was derived, Mr. Edward Hull, B.A., F.G.S. observed that it seems clear that it could not have proceeded from the rocks underlying it, as there was no trace of that substance in the stratum of sandy clay lying immediately under the peat. As sand has the

* See Note at the end.

property of retaining heat for a long time, was it possible that the rays of the summer sun, operating and perhaps accumulating in successive years, might have so far heated the mass of sand overlying the peat as to bring into operation a process of slow distillation at a very moderate temperature? This is the more probable since nature appears to have the power of performing by means of a long time, and a very moderate temperature, operations which the chemist performs in a short time by the application of great heat. He thought the paper a very interesting one; and he begged to move that the thanks of the meeting be given to Mr. Binney for bringing it forward on this occasion.

On being seconded by the Rev. George Perkins, M.A., the motion was carried unanimously.

Mr. Binney observed in reference to the remarks made by Mr. Hull, that a higher temperature than that alluded to by that gentleman, was most probably required for the artificial distillation of petroleum from a substance like this peat.

The President considered it highly probable that the petroleum was produced by means of heat,—heat, however, not derived from an external source. The amount of warmth to carry on the slow distillation already alluded to was most likely to be evolved by means of some chemical process operating slowly upon that part of the bog which was overlaid by a mass of sand, which, retaining the heat, would supply an external agent to prevent the escape of the gases and other products of fermentation, by the combination of which the petroleum was apparently formed.

Mr. Dickinson, F.G.S., said it was not at all uncommon to observe mineral pitch or petroleum oozing from the face of a stratum of coal in our pits, distillation having taken place in the bed where external heat could have no influence.

In the course of the discussion, which was continued some time longer, Mr. Binney remarked that most, if not all our peat mosses are of a comparatively modern date, some of them having evidently been formed within the last two thousand years. These deposits

deserve the careful attention of Geologists, as in and under them the remains of several large extinct quadrupeds may be expected to be found, such as *Megaceros Hibernicus*, the Red Deer *(Cervus tarandus)*, and the *Aurochs*; which last, it is probable, was still a living tenant of our island when Cæsar visited it with his legions. Heads of these animals should be looked for under the peat bogs, and in the drift in several districts in Lancashire and Cheshire. We ought to try to obtain some of these interesting reliques of a by-gone time.

It was proposed by Mr. W. Blackburne, seconded by Mr. Dickinson, and resolved,—"That the thanks of the meeting be given to the President, (Sir J. P. Kay-Shuttleworth, Bart.,) for his able conduct in the Chair."

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*NOTE,—BY THE AUTHOR OF THE PAPER.

The best hypothesis I can propose to account for the phenomenon, is the following.—Before the upper bed of peat was covered with sand, the vegetable matter composing it being freely exposed to air, and in a moist condition, according to LIEBIG, (p. 274 of his Chemistry of Agriculture and Physiology, 2nd Edit.,) would enter into putrefaction; its carbon would be shared between the oxygen and hydrogen of its own substance and of the water; carburetted hydrogen would consequently be evolved, as well as carbonic acid gas, both of which compounds have an analogous composition, (CH_2. CO_2). This effect would continue so long as the peat was exposed to the free action of the air, but when, after having undergone partial putrefaction, it was covered up by a bed of sand, and the air consequently excluded, a part of its carbon would combine with the oxygen of the water, as well as with the oxygen the peat itself contained, whilst its hydrogen, and that of the decomposed water, were liberated either in a pure state or as carburetted hydrogen. When these gases were formed there would be no means for their escaping, but they would be confined as in a closed retort, and if the quantity of oxygen was not sufficient to consume all the hydrogen, new compounds would be formed, such as the petroleum, and other hydro-carbons. This may probably not be the true process by which the substance has been formed, but I cannot suppose but that it must have been produced by a process partly analogous to that which takes place in the destructive distillation of wood in close vessels, where, owing to the limited or total absence of oxygen, the combination of hydrogen and carbon in the form of hydro-carbons is effected.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL SOCIETY.

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MANCHESTER GEOLOGICAL SOCIETY.

No. 3.] [Session 1860-61.

ORDINARY MEETING, TUESDAY, DECEMBER 18th, 1860.

SIR J. P. KAY-SHUTTLEWORTH, BART., F.G.S., President, in the Chair.

Among the gentlemen present were Messrs. Alderman Harvey, Wm. Peace, F.G.S., Jos. Dickinson, F.G.S., Peter Higson, John Fletcher, Andrew Knowles, Thomas Knowles, (Wigan), Thomas Waddington, Rev. G. Perkins, M.A., Elias Dorning, T. A. Readwin, F.G.S,, J. E. Forbes, Wm. Bryham, T. Farrimond, &c., &c.

The following communication was read by Mr. Binney, F.R.S., F.G.S. :—

At the last meeting of the Society I gave a description of a bed of peat containing petroleum, found in the Down-Holland Moss. As there is at Churchtown, near Southport, not far from Down-Holland, a kind of peat of quite a different character from that contained in my former paper, it may be worth while communicating it to the Society. The first-named peat may be termed a blazing peat, and the one about to be described, although as brittle and shining, and having a fracture as conchoidal as the brightest pitch, is a non-blazing peat. On being placed in the fire it burns like charcoal without any trace of flame. It is known in the neighbourhood by the name of "jelly peat," from the circumstance of its

presenting a black jelly-like appearance, something similar to coagulated blood, when first dug up, but, when dried, becoming quite brittle and shining as above described.

On proceeding from Churchtown to the Moss lying to the east of that village, you come to the house of Mr. Linaker, the bailiff to the late Charles Scarisbrick, Esq. About 300 yards further are three drains. By the most western of these, about two fields from the road and close to the drain, with the assistance of Mr. Linaker, I dug down into the peat and found it to be as follows in the descending order :—

	FT.	IN.
Black decomposed peat	3	6
Reddish brown peat, full of the impressions of reeds, containing near its bottom jelly-peat, from half an inch to two inches in thickness.	1	0
Blue silty clay called " Scotch,"...Thickness not determined.		

The brown peat although of a reddish brown colour, when first exposed to the air, in a few minutes became quite black, owing most probably to its rapidly absorbing oxygen from the air. The jelly-peat, Mr. Linaker informed me, had been found to extend over some fifty statute acres of land. It sometimes rested on the blue silt, but more frequently was found about two inches above it. Where it occurred, the peat contained more impressions of the leaves of plants, resembling the *Typha latifolia* and *Acorus calamus*, than the upper part of the bed, which shewed scarcely any impressions of plants, but was a black decomposed peat.

Near to Mr. Linaker's house the bed of peat is covered by two feet of drift sand, brought from the neighbouring sand-hills by the wind. It is very heavy, hard, and compact, and shows very little of vegetable structure. At the edge of the peat where it came from under the sand, there appeared to be a trace of an oily fluid floating on the water in the ditches like that seen in Down-Holland Moss, but

no smell was perceptible from it, The *ignis fatuus* is still sometimes seen on the moss, near Martin Meer, and the Bittern has been found in the same neighbourhood within a few years.

Mr. Linaker showed me a magnificent pair of antlers, apparently those of the red deer, which he had found in the blue silt under the moss, and he informed me that several other lots of horns had been found in the neighbourhood, in the same deposit. He also informed me that a second bed of peat, similar in position to that at Down-Holland, had been found under the bed of peat in several places.

The President said, he feared that he failed at the last meeting clearly to express his conception of the character of the processes by which the peat came to be changed into the state described by Mr. Binney. He conceived that it depended upon two causes—*first:* on the occurrence of a slow combustion in the vegetable matter of the peaty moss ; and, *secondly:* on the evolution of heat by this combustion causing an equally slow distillation. He had since the last meeting, with a chemist of deserved celebrity, in London, worked out the formulæ which rendered this solution of the change not improbable.*

Mr. Binney then drew the attention of the meeting to a specimen of an incrustation, formed inside a piece of square wooden spouting, used for conveying water in the shaft of a coal pit at Chadderton. The incrustation had accurately coated the inside of the spout in which it was deposited, to the thickness of full half an inch, thus forming an inner spout or lining, of a greyish brown colour, of great hardness. He said he had along with the incrusta-

* At page 17 of the last number of the Transactions there is an ERROR in the report relating to this subject, arising from the word CORNISH having been mistaken for COAL, which it may be well to correct in this place. The statement made by Mr. Dickinson was to the effect, that "he had seen mineral pitch oozing from the face of the strata in one of the Cornish mines."

tion received for analysis, a bottle of the water which deposited it. He had not had the water analysed, but he found that the deposit or incrustation effervesced briskly on the application of an acid, and it was no doubt, made up chiefly of carbonate of lime, with probably a little iron. Mr. John Page, of Smithfield Market, Manchester, who had obligingly sent the specimen, had also sent him a written account of the circumstances under which it had been formed. Mr. Page's account is as follows :—

"In the year 1845, a coal pit was sunk at Chadderton, which is known as the Denton Lane pit. It is 160 yards deep, and about 50 yards from the earth's surface, water oozes out of the side of the shaft, and in order to avoid the inconvenience of its falling irregularly to the bottom, 'circle spouts' are placed round the shaft at intervals of ten yards, and the water is conducted from one circle to another to the bottom of the pit, by a series of 'down spouts.'

"A few months ago, some of these spouts had to be repaired, and the incrustation which accompanies this was found, in the upper length of spouting; all the other spouts being found quite free from anything of the kind.

"The colliers say, that although similar spouts are used in nearly all pits, they never saw any lined by an incrustation in this manner before. Horses are employed in the Denton Lane pit, and they regularly drink of this same water, and are very healthy. The workpeople also drink it occasionally with equal impunity."

Joseph Dickinson, Esq., F.G.S., stated that he had seen such incrustations before. They were not so rare as the writer of the remarks just read had been led to believe.

Geological Maps of Lancashire.

Edward Hull, Esq., B.A., F.G.S., in accordance with the general wish expressed at the previous meeting, gave an explanation of the Lancashire maps of the Geological Survey, which were exhibited, along with a large ideal section, in the room.

Mr. Hull said that the maps which were ready for publication, consisted of Nos. 80 N.W. and 89 S.W., on the one-inch scale; and 92, 100, 107, 108, on the six-inch scale of the Ordnance Survey.

Besides these, he stated that the one-inch map, 80 N.E., (containing Bowdon and Lymm); and the six-inch maps, 93 (Wigan), 94 (Hindley), 95 (Bolton), 101 (Newton-in-Makerfield), 102 (Leigh), 103 (Worsley), were all surveyed, and were being prepared for publication.

On these maps, the boundaries of the Geological formations, the dip of the strata, and their nature whenever visible at the surface, the lines of fault, with the amount of *throw* on the down-cast side, the out-crops of the coal-seams, with their names and thicknesses, the depth of the coal pits, &c. are portrayed. Every one-inch sheet is also accompanied by an explanatory memoir, pointing out the principal sections and other points of interest in the district.

It had also been deemed advisable to represent those parts of the country which are overspread by sand, gravel, or boulder-clay, also called "till," belonging to the Post-Pliocene or Drift Period. This could not have been done by colouring, as it would have interfered with the tints used to represent the various formations of the older Geological periods. It had, therefore, been found necessary to mark the drift-surfaces by engraved stippling, formed of very small dots, the tracts of surface where the strata were bare, or covered only by vegetable soil, being left without stippling.

Referring to an "Ideal General Section" through Lancashire, on a large scale, a copy of which is annexed, Mr. Hull pointed out some of the leading characteristics of the different groups of rocks comprised in the following

GENERAL SUCCESSION OF FORMATIONS,

With their thicknesses, in Lancashire and Cheshire.

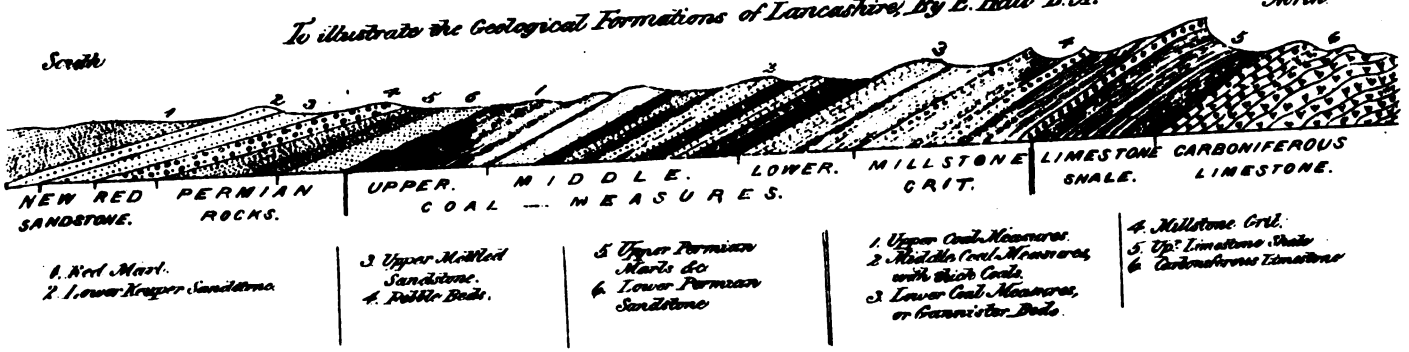
			Thickness,* Feet.
Trias or New Red Sandstone, 4,750 ft.	Keuper	1 Red Marls, (Cheshire)	3,000
		2 Lower Keuper Sandstone and Waterstones	450 to 500
	Bunter	1 Upper Mottled Sandstone	500
	,,	2 Conglomerate beds	650
	,,	3 Lower Mottled Sandstone, (often absent)	100
Permian Series 350 to 650 ft.	1 Upper	Red Marls with Limestones of Leigh, Patricroft, Manchester;	250
	2 Lower	Sandstone of Collyhurst, &c.	100 to 400
Coal-Measures. 6,800 to 7,000 ft.	1 Upper	Reddish shales, sandstones, and Limestones of Ardwick, and thin coals	2,000
	2 Middle	Shales, sandstones, fire-clays and coal-seams, from the Worsley "Four-feet" mine to the top of the Flagstones, below the "Arley" mine	3,200
	3 Lower or Gannister beds	Flagstones, shales, and thin coals, with "Gannister" floors and roofs with Marine Shells	1,800
Millstone Grit 4,000 ft.?		From the "Rough Rock," to the lowest Millstone Grit, also containing thin coals	3,500 to 4,000
Upper Limestone Shale, or Yoredale Rocks, 2,000 ft.?		Shales, generally dark, with flagstones near the top, and black limestones towards the bottom	2,000

*NOTE.—The above estimates of the thicknesses of the formations are nearly identical with those recorded in the "Coal-fields of Great Britain,"—1861. Several measurements have been made with the assistance of MR. BINNEY, particularly those extending downwards from the "Rough Rock." They are, however, only approximations. The series of the middle Coal-measures is very fully expressed in MR. DICKINSON'S Vertical Sections, (Report of H.M. Inspectors of Mines, for 1858.) Descriptions of the coals of the lower Coal-measures, and of the Permian Rocks, are already published in the Transactions of this Society,—vol. I and II, and in those of the Literary and Philosophical Society,—vol. XII. For further details concerning the Triassic Rocks, the reader is referred to a Paper on the "Sub-divisions of the Triassic Rocks in the Central Counties.—Tran. Geol. Soc. of Manchester, vol, II., page 21.

IDEAL

GENERAL SECTION.

To illustrate the Geological Formations of Lancashire, By E. Hall B.A.



Mr Hull then proceeded to trace the limits of the various formations shown on the maps, commencing with the Red Marl—the highest division of the Trias. The range of the Lower Keuper Sandstone, the sub-divisions of the Bunter Sandstone, the Permian Rocks, the Coal-measures, with their minor sub-divisions of upper, middle and lower, and the Millstone Grit, commencing with the "rough rock," were traced in succession. These formations having been fully described on many previous occasions by Messrs. Binney, Ormerod, and other geologists, it was not considered necessary to re-iterate information already published in the Transactions of the Society.

Mr. Hull begged to call particular attention to the section of the Trias, near Ormskirk,* where, in the cutting of the St. Helens railway, the superposition of the two great divisions of the Trias—the Keuper and Bunter—was very beautifully exposed to view. This section was of particular interest, for it exhibited more plainly than any section hitherto discovered, the unconformity of these two divisions to each other.

Another feature not previously brought before the Society, was the occurrence of the Permian beds, at Bispham.† There are two localities where these strata are shown, but the finer section is in Skillaw Clough, and is fully described in the memoir on the "Geology of Wigan." The section shows, at the base, red sandstone corresponding to the Lower Permian sandstone of Collyhurst; next red laminated marls; then a bed of magnesian limestone, five feet in thickness. Above the limestone there appear to be strata of red marl, very obscurely shown in a trench. The whole of these beds repose upon Carboniferous strata of the Millstone Grit series, or at least lower down than the "rough rock," and they are terminated northwards by the great fault which throws down the New Red Sand-

* For a full description and figure of this remarkable section, see "Geology of the Country around Wigan," Memoirs of the Geological Survey, 1860.

† See for figure and description, *Ibid* p. 15.

stone. Thus we have Permian strata resting on the upper Coal-measures, near St. Helens, and along the southern skirts of the coal-field from Leigh to Pendleton; on the middle Coal-measures at Edge Green Colliery, and at Collyhurst; and on Millstone Grit at Bispham. These phenomena all point to the fact, that in this part of England the Carboniferous rocks were disturbed, elevated, fractured, and that vast masses were swept away by marine agency, before the formation of the earliest Permian strata.‡

The great lines of fracture which traverse the district had long been known to many geologists present, as far as they intersected the coal-field. Those in the vicinity of Wigan had been traced on the maps of Mr. Peace and Mr. Farrimond. Many of these faults have been traced, by the author, into the Trias. Thus the great fault which passes by Kirkless Hall, and Bickershaw Collieries, appears to be continuous with the fault which crosses the Mersey west of Warburton, and which had long since been pointed out by Mr. Ormerod, but it was remarkable that it had changed from being a downthrow on the west at Kirkless Hall, to a downthrow on the east at Warburton. The fault which passes by Worsley, Patricroft Colliery, and Eccles Church, has been traced by Timperley, and Wilmslow, in Cheshire. The great Irwell Valley fault was also considered by the author as a continuation of that which crosses the Mersey, at Heaton Mersey, and brings up the Permian marls described by Mr. Binney.§

The general direction of all the great lines of fault was N.N.W. and S.S.E., and it was interesting to observe, that the faults which had been traced across the district extending from the Lancashire coal-field by Liverpool, Birkenhead, and Wirral, belonged to the

‡ I have purposely omitted the mention of the red sandstones of Rainford and west of Grimshaw Delf, both of which rest on Coal-measures well down in the series, as it is still uncertain whether they are to be considered as of Triassic or Permian age.

§ Memoirs of the Literary and Philosophical Society of Manchester, Vol. XII.

same predominant system of fractures. There were also cross faults, the directions of which were rather irregular, and they seldom struck the main faults at right angles, but somewhat obliquely.

The directions of the faults appeared to the author, to be capable of explanation, upon the principles laid down by Mr. W. Hopkins, regarding the physical laws, in obedience to which, such fractures have resulted; the apparent irregularities being due to various modifying influences, such as differences in the cohesion of the strata.

With reference to the most convenient base for the lower Coal-measures or Gannister beds, the author maintained, that the "rough rock" was superior to any other. It had several advantages. First: It was easily distinguishable. Second: it generally formed a well-marked physical feature, and from its solidity, it was its habit to rise conspicuously from beneath the superincumbent strata. Notwithstanding the fact of coal-seams occurring both in, and below the "rough rock," the advantages here enumerated for presenting a true geological horizon, and a convenient base for the main coal-series, entitled it, in the author's opinion, to be placed at the top of the Millstone Grit division. In stating this, the author admitted that it was only a question of convenience, there being, in this part of the country at least, no great physical break through the whole carboniferous series from the upper Coal-measures to the Mountain Limestone. Everywhere the changes from one group of strata to another was gradual, indicating parallel gradations in the physical conditions of land and sea during the long period of their formation.

In conclusion, the author expressed his acknowledgements to the proprietors and managers of the collieries of the district he had surveyed, who had, as a general rule, rendered him every needful assistance.

Mr. Binney said, that in Lancashire for fifty years the "rough rock," Rochdale (Shawforth) flags and Brooksbottom coal series, containing three seams of coal, had always been included in the Lower Coal-field. The "rough rock" was no child of his; it was so classed by Mr. Farey, Mr. Elias Hall, Mr. John Hall, and all other geologists, who had investigated the Lancashire Coal-field; and he still contended that the Upper Millstone of Brooksbottom, was a much better line of division than the "rough rock." The gentlemen of the Geological Survey in their first commencement, had taken the "rough rock" as a millstone grit, they were therefore obliged to follow up their classification in Lancashire; but although the term "millstone grit" was not of much consequence, and might be abandoned altogether, he preferred "lower coal-field" for all the deposits in Lancashire, in which coal had been there worked; still there was no harm in retaining "millstone grit," as it had been used. The Sand Delph or Featheredge coal sometimes occured on the top of the "rough rock," and at other times in the middle of it, which really cut the division of the Geological Survey into two. It was said that the "rough rock" and the millstones were as much alike as one cheese was like another. The resemblance was something like that which existed between a rich Cheshire cheese and a Dutch cheese that was hard enough for a cannon ball. But ask any builder or stonemason if Summit, Ashworth, Horwich, Parbold, or any other specimens of "rough rock," so commonly used in building, were of the same kind and character as Bank Lane, Tintwistle, Bugsworth, or any other "upper millstone." They will tell you that there is a great difference; and the hardness of the millstones is well known to all workers in stone, who require more wages for tooling it than for "rough rock." Owing to the crumbling character of the "rough rock," which is due to its containing a considerable amount of decomposed feldspar, it is much used for the purpose of making sand. Where is the millstone which is so used?

By taking the upper millstone as the boundary of the Lower

Coal-field, you include in it *four* beds of coal, *three* of which have been worked; and you will practically include all the Coal-measures having workable seams in them, in Lancashire. But if you take the "rough rock," you make a millstone grit series of coals in addition to the Lower Coal-field. Now, although as a general rule for Great Britain, the term "coal-measures" may be applied to all the deposits above the Old Red Sandstone, still, in Lancashire, it is more convenient to take the Upper Millstone of Brooksbottom, as the base of the Lower Coal-field, without going down further. The question is one of convenience, and the members of the Society after investigating the subject for twenty years, as he had done, he thought, would find the views which he and other local geologists took of the matter, more convenient for the district, than that adopted by the gentlemen of the Geological Survey, who for uniformity's sake, were obliged to follow the plan originally laid down by their predecessors.

The President: In your sections, Mr. Hull, I think you place the "rough rock" between the gannister and the millstone grit?

Mr. Hull: Yes.

The President: You will remember that in the excursion made by the Society to Padiham, when we had ascended two-thirds of Padiham Heights, both Mr. Binney and Mr. John Hall recognised a particular rock as the "rough rock." I said at the time, that this rock lay higher in the series of strata than a seam of "gannister," with the course of which I was familiar. Since that visit, I have traced that "gannister" three miles along the Padiham Heights, and I brought a bag of specimens of this "gannister" to one of the meetings of this Society. That lay below the "rough rock" identified by Mr. Binney and Mr. Hall. I also brought specimens of another seam of identical rock, (lithologically speaking), and which Mr. Binney recognised as "gannister," which I found in a series higher than the "rough rock" observed by Mr. Binney and Mr.

Hall. There is, therefore, one seam of "gannister" above and another below the "rough rock." My impression is, there is a series of beds of "gannister" interspersed with softer rocks.—The "rough rock" from Padiham Heights is a very friable gritstone—so friable that we pound it with hammers to make sand for garden walks, for which it is well adapted.

Mr. Binney said, that he had only seen one "gannister" coal-floor in Lancashire.

A conversation then took place, shared in by the President, Messrs. Binney, Peace, Dickinson, Hull, and others, respecting the faults pervading the coal-field, the drift so largely distributed on the surface, and the difficulty thence arising of tracing the out-crop of the strata, and the *identity* of seams of coal in distant localities.

Mr. Peace noticed the fact, that besides the vertical upthrow or downthrow of the ruptured strata, there had often been a lateral motion, which still further complicated the phenomena exhibited in faults.

The President observed, that he conceived the coal-fields, in which so many results, the operation of lateral and perpendicular forces were disclosed, presented some of the best opportunities for studying structural geology. For example: from the relative position of seams of coal and intermediate strata, and the character of faults, questions as to the comparative duration of protruding forces, that is, whether they were sudden or gradual, might be studied. In like manner, the relative influence of lateral pressure and perpendicular thrusts might be investigated. No other system of strata offered the same opportunity of estimating the power and direction of denuding forces. The borings and pits of miners gave them also the largest amount of evidence as to the thickness and character of the drift. If practical miners were therefore furnished with a

manual of subjects on which they could make observations important to geological research, he thought that men who had little beyond the practical knowledge of their vocation would be able to record a series of facts, very important in questions of structural geology.

Regarding the difficulty of tracing the limits of the strata, and of identifying beds of rock and seams of coal at distant points in the country for representation on the maps of the Survey, Mr. Hull said he had found it to be very great; indeed, the difficulty arising from faults, drift, &c., would have been insuperable but for the valued and efficient aid afforded by the proprietors of coal mines in different parts of the district. Nothing but the knowledge derived from the record of actual sinkings made through the drift and the strata, would supply the information necessary to enable any one to indicate the position of the different beds of rock, and the interstratified seams of coal in large portions of the Lancashire coalfield. In some cases, where copies of the sinkings could not be obtained, he had had recourse to oral information from working colliers,—men who had formerly been employed in the neighbourhood to which the missing documents related, and he had reason to believe that the information thus obtained was quite trustworthy, since in more than one instance, from accounts of sinkings afterwards recovered, he had been able to test the correctness of the information furnished by the working miners, and he had found it to be, in the main, remarkably accurate; so that it seemed to him, the memories of such men might generally be relied upon in reference to facts which had fallen under the men's own observation. He noticed, likewise, the utility of the Sections published by Mr. Dickinson in his report, as Inspector of Mines for the year ending December, 1857.

Mr. Dickinson said the coal-seams could be identified throughout on the west side of Manchester, but not clearly on the east side,

about Oldham; there being a long distance between, where the upper mines were not yet sufficiently proved.

Mr. Binney said, he hoped the gentlemen of the Geological Survey would give us on their maps, all the dips of the Trias beds, and trace the great fault which runs along the valley of the Irwell, in its course southward under the Trias.

A vote of thanks to the President, for his able conduct in the chair, terminated the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 4.] [Session 1860-61.

ORDINARY MEETING, TUESDAY, JANUARY 29th, 1861.

E. W. BINNEY, ESQ., F.R.S., F.G.S., Vice-President, in the Chair.

There was a very full attendance of members and of scientific men from the neighbourhood, great interest being manifested to hear Mr. Dickinson's account of the Explosion which took place at Hetton Colliery on the 20th of December last.

The following gentlemen were announced as having been elected Ordinary Members of the Society,—Messrs. Thos. Edward Wheatley, Shudehill; John Bolderson, Strangeways; and T. T. Wilkinson, F.R.A.S., Burnley.

The Chairman, in opening the proceedings, said: Gentlemen, since our last meeting, scarcely more than a month ago, the Society has experienced a great loss, in the death of one of our Vice-Presidents, the late Mr. William Peace, F.G.S. Mr. Peace was a gentleman whom I have known for the last 24 years, and I must say I have come in contact with no gentleman connected with

the coal trade who has shown so great a liberality in giving information—and a very valuable store of information he was known to possess—to every one who applied to him. The first time I became acquainted with Mr. Peace, though I had been previously an entire stranger to him, he showed me everything he possibly could respecting the Geology of his own neighbourhood, and I shall never forget the great kindness which I have always experienced from him personally. You know, gentlemen, as well as myself, the very great value of his contributions to this Society. He was a member of it from its commencement, and during the last few years we have had three or four very valuable contributions from him. In the Museum is a very elaborate section of the coal-field of Wigan, contributed by Mr. Peace; and in all my experience of this Society I know of no gentleman connected with the coal trade who gave us such great and valuable assistance at all times, by communicating information of which he was possessed, and in other ways. I am sure it will be a long time before we have his place filled up amongst us.

The Chairman said that he considered it his duty to publicly contradict any erroneous statement which he saw in print respecting fire-damp. Now this invisible and intangible enemy is sufficiently dangerous to the coal miner, often coming suddenly upon him, like a thief in the night, without any misleading as to where it is likely to be present or absent. In a work lately published in America,* and having a considerable circulation in this country, at p. 14, is the following—"In mines of lignite and cannel coal, carbonic acid or *choke-damp* is almost the only gas present." Seams of cannel coal, from being open-jointed, no doubt do sooner allow the fire-damp to be drained from them than from

*A practical treatise on Coal, Petroleum, and other Distilled Oils, by Abraham Gesner, M.D., F.G.S.—published by Baillière.

seams of ordinary coal. However, we who are acquainted with the Wigan district, where more cannel is wrought than from any other mines in the world, on the one side, and those of Dukinfield on the other, know well that fire-damp is sadly too prevalent in them, and accordingly thorough and efficient ventilation, aided by the use of safety-lamps, is or ought to be in use in cannel, as well as coal mines, if explosions are to be prevented.

A Patent Safety Hoist was exhibited, the invention of Messrs. Dodman and Bellhouse, of Rochdale. The thanks of the meeting having been given to these gentlemen, the Chairman called upon Joseph Dickinson, Esq., F.G.S., Inspector of Mines, for his promised communication

On the Cause of the Explosion at Hetton Colliery.

Mr. Dickinson said,—Having, at the request of my colleague, the Inspector of Mines for South Durham, and by direction of the Secretary of State, had to assist in the investigation of the explosion which took place in the Hetton Colliery on the 20th of December last, I found, on investigating the matter, that it was a subject of peculiar interest, and worthy, as I thought, of being brought before the notice of this Society. The Hetton Colliery, as many of you know, is one of the oldest collieries in the county of Durham. It is of great extent, and is under the management of Mr. Nicholas Wood, his principal viewer being Mr. John Daglish. Mr. Nicholas Wood deservedly stands at the top of the coal trade, and he is chairman of the Coal-owners' Association of the United Kingdom. His viewer, Mr. John Daglish, is a gentleman who is not only practically conversant with ventilation, but has a thorough scientific knowledge of it as well; there being really nothing omitted that could ventilate the mine safely. An explosion happening under such management, naturally attracted a good deal of attention. All

connected with the colliery believed that it was one of the underground boilers that had exploded, for such a thing as gas had not been seen for months, nor the slightest indication of it. However, an explosion having happened, a sifting investigation became indispensably necessary. It was proved that no boiler had burst; there were three boilers in the pit, and all were left sound; but a violent explosion had taken place in the flue from one of the boilers, and striking north and south along two main intake levels, direct from the downcast shaft. The force of explosions generally keeps in a straight line, or as nearly so as possible, getting relief at each side opening which it passes, but in this case, owing to the stoppings being so strong, and so well stowed, there was not that expansion at the sides which, otherwise, there might have been. The explosion, northwards, blew men's heads and arms off at 600 or 800 yards; blowing a crossing down at 1400 yards, and setting stables on fire at nearly 400 yards; whilst on the south, the props, as on the north, were blown out; the roof fell down, and at similar distances, up to nearly 1000 yards, some of the heavy iron tubs, laden with coal, had their ends either bent or blown out, and the empty tubs danced about as though they had been bits of paper. About 17 fathoms of the guides and framework of the pit shaft were also blown out, and the arching, &c., about the bottom was blown to pieces, and the crossing, where the flue from one of the boilers crossed the north waggon way, was blown down, and the inner compartments blown up. It was, what I call, a very violent explosion; I have seen more violent ones, but not more than two or three. The loss of life was, fortunately, only 22; I say *only*, because had this happened on one of the day shifts, when the full work was going on, the loss of life might just as easily, and probably would have been 100 or 200.

These plans and sections * show the arrangement of the work-

*The Plans and Sections are hung up in the Geological Room at the Museum, Peter Street, where they may be examined, that room of the Museum being open gratuitously to the public.

ings, flues, furnaces, boilers and steam pipes about the downcast and upcast pits, both as they were before and after the explosion; and also an outline of the ventilation of the whole of the workings. However, it is with only one boiler fire, with the flue, on which I am now going to observe. The other two boiler fires are very near the upcast shaft. This one boiler has a flue which forms three sides of a parallelogram. It goes directly west for about 350 links, crossing over the main north waggon way, which is the main intake to the north side of the colliery, at about 140 links. It then strikes off at a right angle, and goes direct south for about 200 links, turning the corner there at an angle of 45 degrees, and it there joins the drift or flue from one of the west furnaces, just at the tail end of the furnace, at a point where the flame frequently passes; it then goes on eastward, until it is joined by a drift or flue from the other west furnace, and jointly, for about 400 links from the first junction, the boiler fire smoke, and the two west furnace smokes and gas go together to the upcast pit. The boiler flue, after it leaves the boiler fire, is slightly ascending, until it gets to the crossing where it goes over the main north waggon way; there there is an ascent over the arched crossing, and the smoke, &c., would have to make a descent on the opposite side; it then ascends slightly, until it turns south, when it runs about level to the junction with the furnace drift, whence it is a steep ascent to the upcast pit. This arrangement, it was stated, had been going on for 34 years without any accident whatever, or any suspicion of danger. The flue, as it leaves the boiler, consisted of a main way cased with brick and mason work, and the lower part of the inside of this was divided into three arched compartments, leaving a space, or upper compartment above, which, with the two side ones, served to keep the strata cool. The middle one of these three lower compartments was for the smoke; the draught through the boiler fire into it being regulated by an ordinary damper. The smoke went along this flue to near the crossing over the north waggon way, when it opened into and became one with the upper compartment, and

from this point, over the crossing, and to where it joins the furnace drift it is a spacious gallery, high enough to walk in; having the two side compartments continuing throughout separate at the sides. At the point where the lower centre compartment unites with the upper compartment, the upper compartment was open, and smoke might back into it, for nearly half way to the top of the boiler. Here it was walled across, having a man-door, made of iron, in the wall; and again, about midway between this wall and the top of the boiler, this upper compartment was again walled across to send steam, &c., from the top of the boiler down a hole into one of the lower side compartments, and not into the smoke flue. The ordinary ventilation which takes place in any of our under-ground flues, is generally no more than suffices to keep the top of the boiler sufficiently cool for the men to work about it. No more was done in this case, and I believe the general practice is not to do more. The boiler fire was supplied with fresh air from the downcast shaft. On the night shift this boiler was not worked, but was usually filled or banked with coal, and on the night of the explosion the damper was just put down as usual, leaving only sufficient draught to carry off the smoke.

The indications showed clearly that the explosion had first come from within the flue. The arches of these inner flues were blown up and burst out. The boiler was scarcely moved, and not at all damaged. There were signs of flame about the boiler, and on the felt coating of some of the steam pipes; but with that exception, there was no trace of flame left upon the timbers, upon the coal, or anywhere. Neither should we have been able to ascertain that the fire had travelled so far as the stables on the north side, nearly 400 yards, had it not been for the fact of their being set on fire, and the fact of the stables on the other side of the pit being also set on fire. The chemists who gave their evidence at the inquest, thought this might have happened from heated air, and not from flame; however, neither of them mentioned a single instance where

a person had been burned under-ground, or anything set on fire, when out of the flame of an explosion. The quantity of fire had been nothing like what it is in many explosions; for although it does not happen once in three times that when men are burned to death any trace of charring is to be seen on the coal; still, coal is frequently found charred after an explosion, but there was nothing of that in this case. Another thing that surprised me was, that with such immense galleries and ventilation, so small a quantity of flame should have produced such fatal effects by after-damp. Men who were far in, and not exposed to the blast, had been suffocated by the after-damp; in fact the after-damp seems to have been exceedingly strong, so much so, that had the matter not been closely investigated, not only I, but others, would have doubted the possibility of such unusual effects from so small a quantity of flame; the proportion of vitiated air being apparently not much greater than might be expected from burning a sheet of brown paper in a room. This matter was very closely sifted by the Coroner's inquest. I think I never saw an accident more closely, carefully and patiently sifted than this one was. All the workmen who escaped, or who could give any information were examined; also the viewer and his numerous assistants, together with several other viewers, and two chemists. There was no attempt whatever to suppress anything that could throw light upon it. Mr. Wood himself attended daily for the three days it lasted, and both himself and Mr. Daglish seemed as anxious as possible that the truth should be arrived at. Perhaps the verdict that was returned is of greater importance to the coal trade than if it had been found to arise from an explosion of fire-damp, because this opens out to us a new danger; a danger which, so far as I am aware is not guarded against; and if, in any of the under-ground boiler-flues, which we have in this county and other parts of the kingdom, we are to be exposed. to such an explosion as this, it behoves us to get all the information we can, and to take precautions accordingly. At the outset of the inquiry, on seeing the damage done, I and others also, as I am told, supposed an explosion of gun-

powder or fire-damp would be found to have taken place in the workings, besides the explosion in and from the flue ; and at the beginning of the inquest some of the jury said, audibly, they never would believe that this explosion had happened from a boiler flue. However, the inquiry went on, and after the most careful sifting that we could give it, fact after fact stood out until it was impossible to resist the conclusion unanimously arrived at by the jury, that it had arisen from gas in the flue, and not from the workings, nor from gunpowder. There is no other solution of the accident, unless you can suppose that gas came down the down-cast pit, and was being dispersed along the main intakes, and that it had just got to the boiler fire, that the first explosion was in the flue, and that then the main explosion spread to the rest of the pit. It was in the Hutton seam where it exploded, and there was above this seam another called the Low Main, which was not at work. It had not been at work for some years, and it is one of those seams which give off very little fire-damp. I went through this low main, and examined it also, and found there a perfect system of ventilation, with no trace of fire-damp anywhere. Above the Low Main was another seam, called the High Main, which was in full operation, and everything there going on all right, with a furnace in it also, the three seams being ventilated by the same shafts. The effects of the explosion did not extend to these two upper mines at all. Besides, to suppose that any gas would come down the downcast pit, you must suppose it to be in sufficient quantity to foul the immense ventilation, a total of 180,000 cubic feet of air a minute, which was coming down it, which is not likely without some trace being left of the source. Another thing :—all these men in the seam where the explosion took place appeared to have been placed to their work in a regular way ; there was no allowing men to ramble and do as best they could, but they were regularly placed by the properly appointed overmen ; and all, excepting two sets, who were working with large open oil-lamps on the main north intake, had safety-lamps, the lamps being all examined and locked.

There was another point which I thought it necessary to have sifted very closely, lest it might ultimately be found to have something to do with the explosion. A few days before the explosion, the water behind the tubbing, having, by late rains being raised higher than before, burst the wedging, and came down the upcast pit, extinguishing the main east furnace. To get at this tubbing it was necessary to take off the brick-work which covered it, and to work upon a scaffold. The drift and spray of the water were so strong, that it was found impossible to work without slacking the furnaces ; part of the ventilation had to be altered, and the general working of the colliery was stopped during these repairs. However, for two days ordinary working had been resumed, no gas had been seen, and everything was going on as usual ; and after all the examination I could make throughout the colliery, and with all the investigation I could put in force, I could neither find a trace of fire-damp, nor anybody who had seen, or suspected such a thing ;— and there had not been more than a small bottle of gunpowder, in the pit. In fact everybody about the place believed it was the last colliery in the district where an explosion could happen. The ventilation of the colliery was such that there is an immense surplus, and even with all the three furnaces and three boiler fires in the Hutton seam out, there was, after the explosion, when the means had been disarranged, sufficient ventilation to clear all the mine of gas. There is, probably, double the quantity of ventilation in that pit that is wanted for perfect safety. This boiler fire and the engine had been at work during the repairs alluded to, and everything had gone on right during the two days when full work was resumed, and at night the engineman damped the fire as usual, putting on about twelve cwt. of coal, and in about two and a-half hours afterwards the explosion took place.

Mr. Isaac Lowthian Bell, who is a practical manufacturing chemist and iron-master, conversant with gases, gave it as his opinion that the flue itself, if filled with light carburetted hydrogen,

mixed with 9½ times its quantity of air, would be sufficient to account for the explosion. He went further, and said that if the part of the flue from the boiler to this crossing alone, which would contain about 3000 cubic feet of air, and gas mixed, leaving only some 350 cubic feet for pure light carburetted hydrogen, the rest being air, that that would account for the explosion. He said that quantity of light carburetted hydrogen would be all generated and distilled from 152 lbs. of fresh coal. If it were not light carburetted hydrogen, it might be carbonic oxide, and the quantity of carbonic oxide sufficient to cause all this damage might be generated from 49 lbs. of coke. He added that the explosive force of this quantity of either of these gases would be equal to about 75 quarter barrels of gunpowder, each barrel being 25 lbs. If no steam were present, he said that soot in the flue would not add to the intensity of the explosion, but that if steam were present it might somewhat add to the intensity. Professor Richardson, of Newcastle-on-Tyne, the other chemical witness, spoke to the immense explosive power of some of these gases. He concurred in what Mr. Bell had stated, and added that he thought there might have been some olefiant gas present as well. He said he never had found any olefiant gas in our fire-damp, but he thought there might be a mixture of light carburetted hydrogen, carbonic oxide and olefiant. Following those chemists, there were a large number of colliery viewers, who had examined the workings under ground, and gone into the whole subject, and they gave it as their opinion, without any doubt, that this explosion had taken place in these flues, and from gas generated from that boiler fire. Of these viewers the first was Mr. R. Forster Matthews, and the others, Mr. Thomas Emmerson Forster, Mr. Richard Heckels, Mr. George W. Southern, and Mr. Edward Sinclair. Mr. Matthias Dunn, Inspector of Mines for Northumberland, also gave it as his opinion that it had taken place from this boiler fire. I concurred in this view, but such a violent explosion as this taking place in a boiler flue, I thought it better to leave the matter an open question, for further

investigation. Mr. Forster quoted a similar case as having occurred about fourteen years ago in the Felling Colliery. That was a long flue, 400 or 500 yards in length, with brick side-walls and a flagged top, going along inside a larger gallery or drift, and being the first serious occurrence attributed to an explosion in a flue, it seems never to have been generally received as the cause by the coal trade; there being goaves in the colliery it was suspected that fire-damp must have existed. I, myself, have been connected with iron-works for many years where we had the getting of coal for eighteen blast-furnaces, and an immense number of rolling mills, where the consumption was nearly 1,500 tons of coal a day, and I have seen some rough work with explosions of carbonic oxide, which comes off from the blast-furnaces. I have seen the large iron blast pipes blown all to pieces through the neglect of the men to turn off the valves, shutting off the connection with the furnace when the blast-engine has been stopped. The explosive effects of this gas are very violent. In those cases also where the gas is taken from the top of the blast-furnaces, and brought down and used instead of coal for boiler and other fires, unless the greatest care be used to light the gas before it becomes too much mixed with atmospheric air, the explosions are exceedingly violent, and blow all the apparatus to pieces. I have also heard of cases of what the men call "flisks," slight flashes under the boiler, but anything approaching the explosion from this flue is certainly new to me, and I have no doubt, to many present. If on discussing the matter, you should be of the same opinion as the verdict arrived at, some of you may be able to make suggestions as to the best mode of preventing such explosions. I have told you that besides having the fresh air sent through to keep the top of the boilers and strata about the flues cool, no precaution is generally taken to ventilate the flue. It seems desirable to have the flues as direct as possible, and ascending throughout; but if we suddenly change our plan, and begin to ventilate them as has been proposed, with a much larger quantity of air, we may possibly be rushing into a

danger from which we are now free, and be only bringing the gases in these flues up to the explosive point, that is, supposing the ventilation is not carried far enough. I hope that we may arrive at some clear and decided opinion as to what is the best and safest way of working these flues.

On the motion of Mr. I. Booth, seconded by Mr. A. Knowles, the thanks of the members were given to Mr. Dickinson, for his valuable paper.

The Chairman asked if the evidence was clear and distinct about the damper being put down just about the same as usual?

Mr. Dickinson replied that it was.

The Chairman added that it was strange that after this had been going on for thirty-four years such an extraordinary result should have been produced without some alteration.

Mr. Dickinson—I have all the evidence here, and it seems very faithfully reported. The inquiry was very thoroughly gone into. The damper was broken right through the middle.

Mr. Booth—You said that probably the water flowing from the upcast might have something to do with it, but you did not give us your opinion.

Mr. Dickinson—I rather purposely left that point open. I see here one or two chemists of European reputation, and I thought possibly they might have something to suggest on this matter. The water could not get to the boiler flue. If this explosion was caused by 3000 cubic feet of explosive mixture, it has been of a more explosive nature than ordinary fire-damp. I believe that there were more than 3000 cubic feet of explosive mixture.

Professor Roscoe, F.C.S., said it was pretty clear that the first explosion took place in the flue, and that it was sufficiently strong to blow the crossing down. Free vent would then be given to it, and it would get sufficient air and spread right and left.

Mr. Dickinson, in answer to further questions, said that there was brick work at the sides, and that the boilers were of the single flue kind.

Professor Roscoe, on being called on by the Chairman, said it would be presumptuous in him to offer an opinion, as this was the first time he had heard of this explosion, but after the interesting description given by Mr. Dickinson, there were a few points that suggested themselves. In the first place, the damper being down, it was supposed that carbonic oxide and light carburetted hydrogen had been formed in the flue. Of course this could only be the case where there was a diminished supply of air. He could not account for the presence of these gases in the flue, and suppose that the explosion began there at the same time. In order that an explosion should take place, the gas must be mixed with a certain proportion (9½ times its volume) of air. If there was no excess of air, how came the explosive gas to be formed at all? If the explosive gas was generated by the want of air in the flue, the explosion must have begun where the explosive gas came out into the main flue ; there it would be mixed with the requisite quantity of oxygen to cause an explosion. He could not see how the explosion could begin in the flue itself, unless there was an opening separate from the boiler fire, by which atmospheric oxygen could enter, and he begged to ask Mr. Dickinson if this were the case.

Mr. Booth remarked there was a top flue and a bottom flue.

Mr. Dickinson—The middle flue took the smoke from the boiler fire.

Professor Roscoe—Then the supply of air did come in another way ?

Mr. Dickinson—The general opinion is that it tailed back and fired at the boiler furnace ; but it was thought also to have fired at the nearer of the west furnaces, but not violently until it got over the crossing. It had got into the flue evidently before the main explosion took place, because everything was blown out.

Mr. John Knowles asked if the soot and sediment might not have further stopped the current of air.

Mr. Spence—There is another way of explaining the matter, which is this. Supposing at the time the fire was banked up with fresh coals, there was a large quantity of red fire, with a very limited supply of air, the heat would be sufficient to carry on the distillation of the coal, and the very small quantity of air which was coming in would only be sufficient to convert the results of the combustion of the lower part of the fire into carbonic oxide gas. The result would be the distillates of the coal, chiefly hydro-carbons and carbonic oxide, all highly combustible. This might go on for a certain time, till the heat would get down, and probably allow sufficient air to pass to carry the combustion right through, and the flame would come in contact with the contents of the flue. The flue being old, and its draught checked, would probably allow percolation of air into itself from the roadway.

Mr. Dickinson—Most persons thought the most likely place for the explosion was at the boiler fire. Mr. John Knowles suggests that the damper might be choked up. It was usually left up about an inch and a-half, to be decided by the engineman's judgment, or sufficient to prevent back smoke,

Mr. A. Knowles—None of the dead men were found near the boiler.

Mr. Dickinson—No : but the engineman's burnt jacket was found near the boiler.

The Chairman—Is the man alive who had charge of the damper ?

Mr. Dickinson—Yes : and gave his evidence : both the engineman and the stoker.

Professor Roscoe—At the point where the great explosion is supposed to have taken place, were the walls very thick ?

Mr. Dickinson—No : the crossings are generally very weak places. An explosion would knock them down at once. The flue was in good order.

Professor Calvert, F.R.S., on being requested to give his opinion, said he thought Mr. Spence had given the best insight into the origin of the explosion.

The Chairman thought that very little was known of the generation of these powerful gases, either in the mining or chemical world.

Professor Calvert said that a French metallurgist-chemist * was subjected to dreadful pain for years through accidently inhaling a small quantity of oxide of carbon, which he had endeavoured to prepare for commercial purposes. He had witnessed the formation of these gases in blast furnaces, such as the case referred to by Mr. Dickinson. In one or two instances, in Wales, he had seen fearful destruction of property from this cause. It was very likely that oxide of carbon would, for want of sufficient air, be generated under the circumstances narrated. He gave Mr. Dickinson credit for explaining the facts in a very lucid manner.

Professor Roscoe had no reason to doubt the accuracy of Mr. Bell's figures, which were taken from the best sources, and from

* Mons. Chenot.

them it seemed probable that force enough to cause the explosion might have resulted from the generation of these gases, and the want of pure air.

Mr. Longridge, C.E., said he had known similar explosions in boilers, and from probably the same cause. He mentioned the details of one case where an explosion took place on the fire-door being opened.

Mr. Dickinson—Did they let fresh air in ?

Mr. Longridge—No : but air entered on opening the fire-door for the purpose of throwing in fresh fuel, and, on mixing with the gases collected in the flues, an explosion ensued. In order to improve the draught, a communication had been made direct from the end of the boiler to the chimney, by pulling out a few bricks from the partition-wall. This would prevent that rapid current underneath the boiler which had been there originally. If the bricks had not been taken out the whole of the draught would have been under the boiler into the chimney, and there would have been no accumulation of carburetted hydrogen in those flues.

Mr. Dickinson—From the experience you have had, Mr. Longridge, do you think it is better to ventilate them, or to let no air enter excepting through the fire ?

Mr. Longridge—The only thing should be to allow air to go in through the fire door above the fire. The practice is, in most cases, to admit no air excepting through the grate ; the consequence is, there is a quantity of carburetted hydrogen and carbonic oxide, and no air to mix with it, so that the gas passes away unconsumed. If you permitted air to enter, the gases would be ignited as they were produced.

Mr. Dickinson—But in this Hetton flue the fire was damped

down for the night, and the boiler fire-doors were set open to allow as little draught as possible. Would you consider it safer to work a flue like this with fresh air admitted into the flue ?

Mr. Longridge—I suspect in this case they had filled up the fires as they usually do, almost entirely to the boiler bottom. It is the common practice in the north of England; in fact, they would stop all admission of air by the fire-door. The result must be a large generation of gas. There is one thing possible : if they had increased the draught at the furnaces used for ventilation, it might have had the effect of drawing in a little more air. Of course we do not know in what state those fires were ; but they might have increased the draught at the moment, and might thus have effected this to some extent. I know a similar case of an explosion that occurred with a multitubular boiler, and there was also a flue underneath the boiler, with a damper in front. The gentleman to whom the mill belonged went to the back end, and opened the smoke-box door, to show a friend how low the temperature was in the smoke-box, and while he was there the fireman, not knowing of his presence, threw on his coal as usual, and went to the next boiler; but observing that his damper, which worked on a swivel, had shut, and that the smoke and gas were coming out at the fire-door, he stepped back and turned the damper to give the draught as usual; immediately he did that, a flame, carried by the current into the smoke-box, ignited the gases accumulated in the flues below, and an explosion took place which burned both of the gentlemen very severely. It was simply his opening the damper and increasing the draught which caused the explosion.

The Chairman—Are those the only instances of which you know ?

Mr. Longridge—I know another instance of an ordinary two-flue boiler; but there they were making use of sawdust as well, and the gas got mixed with it.

Mr. A Knowles thought this might happen through the coal forming a ledge, and the gas coming against it.

Mr. Dickinson—In talking this matter over with Mr. John Mercer, of Wigan, he said that on having one of his house chimneys swept with a bush, a violent explosion took place, which blew his windows out.

The Chairman—Do you not think, Mr. Longridge, that the application of air in front of the fire-place is as good a remedy as can be suggested ?

Mr. Longridge—That would effectually prevent it, because you would be then igniting the gas as you produced it. If there had been a direct communication it might not have occurred ; there would have been a sufficient current of air to carry it all away.

Mr. A. Knowles—The north of England coal contains a great deal of gas. With many coals this explosion could not have occurred.

Mr. Dickinson—The quantity of gas which this coal contains is very little more than is contained in the coals here. This is not a celebrated gas coal, but the best house coal.

The Chairman—A very small quantity of carbonic oxide would kill ; it is the most fatal gas known. A general impression prevails among the officers and men in mines that where flame exists there life can. This would be true as to an atmosphere of carbonic acid (choke-damp), nearly pure, but if such a gas were mixed with nitrogen, a flame might burn, and still a man be struck down. A flame also will burn in mixtures of atmospheric air and sulphuretted hydrogen gas, and atmospheric air and carbonic oxide gas, where life will be instantly destroyed.

Mr. Dickinson—All accidents we have previously had in under-

ground flues have been by suffocation; death has been occasioned whilst the man's candle or safety-lamp has been left in his hand burning. But such gas must have different properties from this. In South Wales, about two years ago, a large number of men were killed with lamps and candles burning in their hands, by gas coming from under-ground boiler fires, but there was no explosion. In the coal mines here we have had similar cases, two since I have been inspector; one at Halshaw Moor, where the men were so suffocated, when coal was on fire in the mine. I, myself, have helped to carry two men out of the gas when our safety lamps were burning; and there are instances, where such gas has come out of rocks, and after gunpowder has been fired. It is known as white-damp, in contra-distinction to black-damp, which extinguishes lights before life.

Professor Calvert—M. Leblanc found that one per cent. of oxide of carbon proved fatal to animals. In five minutes animals died from inhaling air containing that proportion of this gas.

Mr. Dickinson—We may not have another opportunity of seeing so many talented gentlemen present; could any of you throw out a suggestion for the prevention of accidents of this kind.

Professor Calvert—I should say the best means would be to secure perfect combustion, and not damp the fire down at night, because that will produce distillation of the coal. The more you increase surface combustion the less danger there will be of explosions.

Mr. Dickinson—Do you think it undesirable to have an elevated part in the flue, as in this case, and then a depression following?

Professor Calvert—I think it would be better straight, so as to reduce the chances of accumulation.

Professor Roscoe—I think Mr. Longridge's suggestion is the right one, of letting in the oxygen above the fire. You want a small fire because you do not want to waste your fuel and steam during the night. If, then, you supply oxygen above the fire, all source of danger ceases. It comes to the same thing as Dr. Calvert's suggestion, only he would supply the air above the fire instead of below.

Mr. Longridge—I consider the opening of the door is of no value, because they fill the fire-place with coal to the boiler bottom.

Mr. Dickinson—Then do you think it would be desirable to have fresh air admitted at the back part of the boiler ?

Mr. Longridge—No : through the fire-door, and not allow them to fill the coal so high.

Mr. A. Knowles—The air could go in through the damper. As it is now, the aperture is at the bottom of the damper.

The Chairman—What you wish, Mr. Longridge is to prevent the stewing of the coal, which is done to save trouble.

The Chairman expressed the thanks of the meeting for the attendance of so many scientific gentlemen, and said he hoped that more information would soon be imparted respecting carbonic oxide, which was a fearful enemy to the miner, in addition to fire-damp. On reading the report of the proceedings of the Coroner's inquest on the bodies of the unfortunate men who lost their lives by the late explosion in the Hetton Colliery, especially the evidence of Mr. Bell and Dr. Thomas Richardson, it appeared to me that this explosion had some resemblance to one which occurred at Stockport about twenty years since.

It has long been my opinion, that in addition to light carburetted hydrogen, or fire-damp, being present in coal mines, another most deadly and explosive gas has been found in them, namely, carbonic oxide, CO, having a specific gravity of 0·9706. In a lecture, delivered by me, some time since, to working colliers, at Burnley, and printed in No. 42 of the Popular Lecturer,* on "Gases in Coal Mines," I stated, "Another most deadly gas found in mines where coal has been on fire, or where boilers are employed under ground, is carbonic oxide, composed of one of carbon and one of oxygen. This gas is one of the most poisonous known, and, unfortunately, gives little evidence of its presence."

The explosion which took place at Stockport, previously alluded to, occurred as follows, as far as my memory serves me, for I have not been able to lay my hand on the report of the scientific evidence given on the Coroner's inquest.—An old fashioned hay-stack boiler, attached to a steam engine, had been at work up to late on Saturday night, and the engineman wanting to quench the fire in the grate as speedily as possible, turned a tap which let out the water from the boiler, at the further end of the fire-place, and left the water trickling down on the hot coal and iron, and the tap open during the night. The next morning he opened the man-hole, for the purpose of examining the inside of the boiler, and having procured a ladder, descended into the boiler with a naked light; a fearful explosion took place, which blew off the top of the boiler, and caused considerable damage to the premises. The poor man was blown high up in the air, and on reaching the ground, wrenched open, with nearly super-human strength, a strong door, after which his sufferings were put an end to by death. The late Dr. Dalton, and some other chemists who investigated the matter came to the conclusion that the gas in the boiler which exploded consisted of carbonic oxide, hydrogen and atmospheric air.

* Published by John Heywood, Manchester, and Kent & Co., Paternoster Row, London.

It is known that when vapour of water is passed over well burnt charcoal, kept at a red heat in a porcelain tube, decomposition takes place, and hydrogen, carbonic oxide and carbonic acid are produced. 100 volumes of the gaseous mixture so obtained, contain 56·21 hydrogen, 28·96 carbonic oxide, 14·63 carbonic acid, 0·19 marsh gas. When common charcoal, not previously ignited, is used the gaseous mixture contains 7·55 measures of marsh gas, which is likewise evolved when the charcoal is ignited alone. When a large quantity of vapour of water acts upon a small quantity of charcoal, the hydrogen gas produced is accompanied chiefly by carbonic acid, with a small quantity of carbonic oxide. All metallic oxides which give up their oxygen to charcoal at a strong red heat, as oxide of zinc, black oxide of iron, and protoxide of manganese, convert the carbon either into carbonic oxide, or a mixture of that gas with carbonic acid. Iron furnaces in their gas afford from 25 to 35 per cent. of carbonic oxide; copper, 13 to 19 per cent. Carbonic oxide is likewise formed when carbonic acid comes in contact with charcoal or iron at a red heat, and gives up to these substances its second atom of oxygen, which is less intimately combined than the first.—(Gmelin's Handbook, vol. XI., page 88.)

From the above authority it seems clear that the water flowing over the hot iron and coke, assuming the latter substance to have the same effect as charcoal, would produce carbonic oxide and hydrogen, as was the opinion of Dr. Dalton, in the Stockport case.

The Hetton case presents some different circumstances to the Stockport one, but I think sufficient evidence has been brought before the Society to-day to shew that it resulted from an explosion of hydrogen, or light carburetted hydrogen and carbonic oxide gases in the flue of the boiler.

Professor Calvert added that the effects of oxide of carbon on

the human system were most extraordinary, and it was to be regretted that so little was known respecting it, seeing that it was produced almost as abundantly as carbonic acid. All our boilers and tall chimneys produce it, and if a very small quantity had produced such astonishing effects, as in the case of Mons. Chenot, who, from inhaling one inspiration of this gas, was made seriously ill for several years, what may not be its action when thus generated, and not removed by rapid currents of air or high winds, from the atmosphere of our larger towns?

Mr. Dickinson—It would startle colliery men to find that where there are under-ground furnaces and boiler-fires, all working into the upcast pit, which is in reality nothing but a large chimney, the gas is so deadly. It is no uncommon thing for men to go up and down the upcast pit, and, with slackened fires, sometimes to remain there for an hour, yet we do not have these ill-effects produced that you describe.

Professor Calvert—Because there is perfect combustion in those cases.

Mr. Dickinson—No: there is a good deal of imperfect combustion.

Professor Calvert—But there must be a large proportionate amount of air in the shaft. If the ventilation were so bad as to leave one per cent. of oxide of carbon, the men then would be suffocated, and find their way down the pit faster than they could go up.

This closed the discussion.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 5.] [Session 1860-61.

ORDINARY MEETING, TUESDAY, FEBRUARY 26th, 1861.

E. W. BINNEY, ESQ., F.R.S., F.G.S., Vice-President, in the Chair.

Mr. William Kellett, of Wigan, was elected an Ordinary Member of the Society.

LOCKS FOR MINERS' SAFETY LAMPS.

Joseph Dickinson, Esq., F.G.S., Inspector of Mines, exhibited a new kind of Lock for Safety Lamps, that has been proposed by Mr. P. H. Holland, one of the medical inspectors. It is called "A Sealed Lock for Miners' Safety Lamps." He said Mr. Holland had laid the matter before the Society of Arts, and in a printed paper accompanying the specimens of the lock sent to him it is stated that—"A cheap, convenient, and secure means of preventing safety lamps being opened without the certainty of detection, would render explosions of coal mine gases almost impossible, for there is no well-authenticated instance of explosion from a proper safety lamp, and men would not venture to open their lamps if detection were

certain, and punishment consequently inevitable. The locks for lamps in common use are not secure, and locks with complex wards and tumblers, though difficult to pick, would be costly and inconvenient. Mr. Holland, one of the medical inspectors of the Burial Department of the Home Office, has adapted a seal lock for safety lamps, which he freely offers for the use of colliers. It consists of a narrow strip of thin brass, with the ends so punched that they can be locked or riveted together in an instant by squeezing them with pincers. The strip is to be passed round any two parts of the lamp, which must be separated in opening. The lamp cannot be opened without breaking the seal. The danger from the men lighting pipes by drawing flame through the gauze, may be prevented by surrounding the lamp with a glass, as in Stephenson's lamp and others. Mr. Holland has just been informed that a lock on a somewhat similar principle has been made, but not much used. He trusts, however, that the plan will be fairly tried, or a better one contrived."

Mr. Dickinson, in continuation, said that Mr. Holland, wishing to know the opinions of some of the inspectors of coal mines upon this seal lock, had sent it to the Secretary of State, and that it had been referred to him to report upon. He had stated that the person who had invented a lock on a somewhat similar principle was an old colleague of his own, who, a while ago, took some trouble to bring it into use, but that, so far as he knew, without any practical result. In this lock there is a sort of nut which goes into a socket, and it has to be pressed together with pincers. There is no doubt that a lock on a safety-lamp is a most desirable thing. The ordinary workman does not think the manager of the mine is in earnest in requiring the lamp to be closed unless it is locked, and when once locked he (Mr. Dickinson) did not think the kind of lock was of much importance, there being the greatest possible difference between unscrewing a thing that is open and picking a lock. Besides, some colliers have been known, whilst sitting down

at rest, by fumbling about the lamp, to have inadvertently unscrewed the lamp. The great point is to have "a lock," no matter how simple it is. In this district there are many simple locks, and if proper attention on the part of the manager is shown not to allow of the lamps being opened with impunity, these simple locks answer all the purposes intended. He would be glad to hear the opinion of any of the gentlemen conversant with the subject whom he saw present on this occasion.

In reply to a question from Mr. Livesey, Mr. Dickinson said the thin strip of metal constituting the lock is to be broken every time the lamp is opened, and a fresh strip or lock has to be used when the lamp is re-locked.

Mr. Livesey said he considered this lock would be effectual in preventing the lamps being opened without detection; and, so far as he could see, he thought favourably of it.

Peter Higson, Esq. F.G.S., Inspector of Mines, said he had had some of these locks sent to him for his opinion. He had not yet reported, but he intended to report favourably upon them. He quite agreed with Mr. Dickinson that a simple lock would answer every purpose for which a lock is intended. One thing to be feared in regard to this strip of metal was that if adopted nominally as a lock, the lamps would be too frequently given out without it.

Mr. Farrimond thought that a lock, though simple, ought to be such as would prevent colliers from opening it.

Mr. Livesey—I think they could not open this without detection.

Mr. Dickinson—No, and a man who would pick a lock would put a lucifer match in his pocket, and break the rules readier in that way.

Mr. Wm. Blackburne thought these locks would be liable to be broken accidentally, and, that being the case, men might be

tempted to break them open and allege that they had been broken by accident.

The Chairman—I think too many lamps have been used in mines without locks at all. If they had common locks I don't think that many colliers would try to pick them. There is a statement in the printed paper accompanying these locks which would have been better left out. It is said that " a cheap, convenient and secure means of preventing safety-lamps being opened without the certainty of detection, would render explosions of coal mine gases almost impossible, for *there is no well authenticated instance of explosion from a proper safety lamp.*" Now, I say there are many instances. The inventor of the Davy lamp never said it was impossible to explode fire-damp by one of his lamps, because he knew it could be exploded, and he always cautioned people not to move against a current of air. We know that lamps are commonly moved against currents of air. He never expected there would be coal dust accumulated on the wire gauze and then oil spilled upon such coal dust, and the lamp, without being cleaned, allowed to become full of flame. I have myself passed flame through standard gauze which has been covered with coal dust and oil. It is well known that lamps are frequently covered with coal dust, and nothing is more common than oil to be spilt on them. Yet here is a gentleman who sends forth to the world a lock with this dangerous advice—that " proper safety lamps cannot be exploded." I should like to ask the gentlemen present whether it is not possible to explode a safety lamp.

Mr. Livesey—I think not under ordinary circumstances—if it is a good lamp and in proper order.

Mr. Dickinson—The remarks of the chairman are very proper; but I have not in my experience had a case where fire-damp has fired through a safety lamp in good order. I have had cases, where the lamp has been out of order, by not having a hoop at the

bottom of the gauze, or where there has been a hole in the gauze, or the pricker hole too large. With the gas that we use in our houses there is not that difficulty in firing it through the gauze; but I have played a jet of fire-damp upon the lamp until the gauze was red hot, and have not succeeded in firing through a Davy of the proper mesh. Should we, however, come upon a gas more explosive than usual, it might go through, and therefore I agree with the chairman that the precautions which he names should be practised.

Mr. Livesey—I know one case where a safety lamp did fire, and several men were killed. The man finding the lamp get hot, laid it down; the others thinking that if left it might be burnt through, one man went to fetch it, but it was so hot he let it fall, and the oil running out, it exploded.

The Chairman—This fact supports my assertion that a proper Davy lamp can explode in gas. In these unfortunate cases there is generally no man left to tell the tale, or we should hear of many cases of explosions caused by proper Davy lamps improperly used.

Mr. Dickinson—Many of the locks we have in use answer the purpose very well; and as their use can be so easily set aside, by carrying lucifer matches, it seems more desirable to rely upon discipline than to magnify the advantage of any particular kind of lock.

The Chairman—It would be very easy to break this [holding up one of the strips of metal], and say it was done by accident.

Mr. Atkinson—Whenever broken whilst in the hands of the men, whether by accident or otherwise, there should be a fine levied for it.

Mr. Dickinson—But fines are very serious things with working miners. Such a regulation would be productive of great hardship.

Mr. Atkinson—The infliction of a fine for a result that might be brought about by accident would probably be considered a harsh proceeding, and might occasionally be productive of hardship, but, like any other misfortune, such a hardship might very well be endured, seeing it would arise from the operation of a rule the intention and tendency of which would be to secure the safety of the men. You could not adopt this lock without instituting some such regulation.

Mr. Wm. Blackburne—I think if a lock must be used, it ought to be a proper one. Owens's is the best I have seen.

Mr. Dickinson—That is a double lock?

Mr. W. Blackburne—Yes: if you have to use any, use a double one.

Chairman—I think if there is much fire-damp, the lamp should go out.

Mr. Dickinson—Stephenson's is made on that principle. In Belgium no lamp is allowed which is not constructed on that principle.

This terminated the discussion on Mr. Holland's "Safety Seal" for miner's lamps.

On Petroleum in Coal Mines.

Mr. Dickinson said that at one of the meetings held some time ago, when no reporters happened to be present, the secretaries, in doing their best to report in contracted writing, had got the words "Cornish mines" to read "coal mines," by which means he was made to state that he had seen mineral pitch oozing out from the

face of the coal in some of our coal pits. What he said was, that he had seen it oozing out from the face of a level in one of the Cornish mines. He continued: I have named this circumstance in order to ascertain if any gentleman present has seen petroleum ooze from the coal strata, as I have been in several hundreds of coal pits in all parts of this kingdom, and several abroad, and have not seen it.

The Chairman—I have had a good deal of experience in this way. Some twelve or fourteen years ago I went into Derbyshire to look at a spring of petroleum. I have seen them also at Wellington and Colebrook-Dale. At Wigan there was a celebrated burning well which yielded oil; and there are I believe some oil-springs in other coal fields. I have myself seen more petroleum coming from coal than I ever heard of in the Cornish mines. In all parts of the world where petroleum is found, it is generally assumed there are great masses of coal or bituminous shale in the immediate vicinity. It has been artificially obtained by distilling coal at a low temperature.

Mr. Dickinson—In Derbyshire, was the petroleum to be seen running out from the coal?

The Chairman—Yes: and some of it from the roof.

Mr. Dickinson—The burning-wells are generally caused by the fire-damp issuing from below, and which may be set on fire as it rises out of the water.

Mr. J. Taylor, jun.—There is some petroleum in the "Blue John Cavern," near Castleton, in Derbyshire. It is in the limestone.

Mr. Dickinson—Mineral fat, called Hatchetine, also is found in the inside of some of the balls of ironstone of the "spotted vein" at Dowlais, in Glamorganshire.

The Chairman—About Colebrook-Dale and Wellington there are several springs. It came out in the neighbourhood of the coal or from the shales above.

Mr. Livesey, Mr. Blackburne and Mr. P. Higson stated that they had never seen petroleum springs in any of the coal pits in Lancashire.

The Chairman—You will see them mentioned, I think, in Bishop Watson's Essays. There are not so many here as in some other coal fields.

ON BLOWERS, OR OUTBURSTS OF FIRE-DAMP IN COAL PITS.

The Chairman stated that he had seen a notice in the London Review about an extraordinary amount of gas that had burst out in one of the mines of the Kirkless Hall colliery, and how successfully it had been removed. He asked Mr. P. Higson if he could give some particulars respecting it.

Mr. P. Higson—It happened some time ago, and the particulars are given fully in my annual report. The outburst of gas to which the chairman refers was so great as to overcome the ventilation. It escaped from the floor between the side of a pillar and the goaf, about two feet from the working face of the coal, in the Arley mine, at the Kirkless Hall colliery, in August, 1859. I had been previously through the workings, and found the ventilation all that could be desired. After the outburst Mr. Lancaster sent for me again, and when I reached the spot I found a rip in the floor of some thirty or forty yards in length, into which I could put my arm up to the shoulder. The description of the outburst given by the overlooker was that the gas was given off with very great rapidity when all the colliers were at work. One of the men who was working there at the time told me that he perceived his lamp was full of fire-damp, and

that he immediately drew down the wick with the pricker, and called to the other workmen to do the same. An alarm was thus spread through the workings, which are very extensive, more than 350 people being, I dare say, engaged there. In the short space of three or four hours the gas had filled the intake air course for 1000 yards, the ventilation for a time being completely overpowered. In that condition it remained for 12 or 18 hours, when the ventilation, without any alteration or improvement being made, rectified itself, and swept harmlessly away the whole of the gas which had accumulated. I attribute the safety of the men in this instance to the lamps throughout the entire colliery being in a state of perfect repair, and to the maintenance of strict discipline. In some parts of the mine there was as much wind as a man could bear whilst he was working, and more air for ventilation would have been objectionable to some of the men, still the outburst of gas overpowered and vitiated it, but fortunately the lamps were all perfect, and they were put fairly to the test. I have no doubt this has been the means of causing safety-lamps to be used more generally throughout the Wigan district than they were before.

Mr. Atkinson—Is the mine where this outburst took place remarkable for fire-damp?

Mr. P. Higson—Yes: the Arley mine, under whatever name it is known, throughout its whole extent, gives off fire-damp.

Mr. Farrimond—Somewhat previous to the occurrence now under notice a collier in the Peacock mine heard the roof break, and the gas issue out like high pressure steam. It went past all the men, and burnt in their lamps about ten minutes, but as the men went towards the mouth of the pit to make their way out, it disappeared. Of course had there been a defective lamp, an explosion would have taken place, the cause of which might never have been known.

Mr. Dickinson—An outburst is quite possible in this mine, but there is no doubt the explosion which occurred there before either Mr. William Blackburne or Mr. Farrimond had charge of the ventilation was from inadequate ventilation.

Mr. Farrimond—These outbursts of gas show the necessity of using safety-lamps.

Mr. Livesey—Do you recollect, Mr. Higson, the instance in the mine at Edge Green where the fire-damp burst through the roof?

Mr. P. Higson—Yes; I never before or since saw so much fire-damp as the outburst at Edge Green. The moment I got to the bottom of the pit I heard the blower giving off gas, which roared like steam escaping under great pressure, although it was several hundred yards from where I then stood. It could be heard distinctly for a very long distance underground, like a waterfall on a summer evening.

In reply to a question whether, as in the case at Kirkless Hall previously mentioned, the ordinary ventilation was sufficient to clear the pit of this gas, Mr Higson said—the quantity of gas which was emitted for a long time was so great that preparations of an unusual character become absolutely necessary, and, until they were completed, operations in that district were partially suspended. Subsequently, the return gas from the locality of the blowers was passed along a return air-course made specially for that purpose, and through a dumb drift to the upcast pit.

Mr. Dickinson—Was it quite clear that none of the gas came out of the old waste?

Mr. P. Higson—I could never find gas in the waste. I should

think the return air-course was more than seven feet wide and six feet high for a mile in length.

The Chairman—I think that in a coal mine there are ample reasons for persons to be always on their guard. It is a terrible thing to have to fight an invisible and intangible enemy like fire-damp, which comes without giving any warning.

Mr. Dickinson—But we know how to deal with it, and we know its indications. The misfortune is, that people won't recognise its existence till it is upon them. They do not in some cases send a fire-man round, nor use safety-lamps unless fire-damp has been found "to prevail," as it is called. It is not that we do not know how to deal with it, but that the means which we have at hand are not taken to conquer it.

Mr. P. Higson—In the case of the Kirkless Hall outburst, I believe no ordinary amount of ventilation would have carried away or diluted that gas, if other precautions had not been taken, and if safety-lamps had not been used and strict discipline maintained, an explosion would most certainly have taken place.

Mr. Dickinson—The means of preventing explosions are well known, the precautions required being good ventilation, careful firemen, and safety-lamps, which may be easily adopted and carried out by any ordinary colliery manager.

The Chairman—It is the ignorance which prevails as to the nature of the enemy. The cost of lamps, managers and ventilation is nothing compared to the loss of property and life by an explosion. I don't think if masters knew the nature of the enemy they would grumble at the expense. Ignorance of the nature and occurrence of fire-damp is the great evil we have to contend with.

Mr. P. Higson—How can they plead ignorance when they know it may be suddenly liberated in the same way as it was at Kirkless Hall?

Mr. Dickinson—Some of the cases of an outburst of fire-damp which I have met with have been from the Wigan five-feet, the Pemberton five-feet, the Pendleton, Crumbouke, and other seams, as well as the Arley mine.

Mr. P. Higson—It was in the Wigan four-feet seam I found the blowers previously mentioned—they were issuing from the roof at the Edge Green colliery.

The Chairman—The more people know of it, the more careful they will be with it. But about a practical man having what is called a practical knowledge of fire-damp doing strange things, I remember the late Mr. Moses Mills informing me that near Oldham it was a common practice to try for fire-damp with a lighted candle, cutting off the long flame as it rose with the hand. These so-called practical men did some terrible things. Mr. Mills said he had worked for 30 years in coal pits, and had done the same thing, without being burnt.

Mr. P. Higson—I remember an instance in my district of an underlooker going with a naked candle, followed by a fireman with a safety-lamp to examine the workings. The underlooker with his candle fired the gas, and was killed, and the explosion caused the death of the fireman also.

On a Mineral Spring in Germany which is Influenced by the Pressure of the Air.

Mr. Atkinson being called upon by the chairman, said he had had a translation made of a small German work, by a Dr. P. Cartellieri,

which was presented a few months ago to this Society by James Hertz, Esq. It related to a subject which might be interesting to some of the members, he had therefore brought the translation with him, but as it was too long to read through at so late a period of the meeting, he would confine himself to giving a brief outline of its contents. The work may in English be styled, "The Francis Well at Eger, and the Atmospheric Pressure." It relates to one of the mineral springs in Germany, at a place called Eger, a few miles to the west of Carlsbad, so celebrated for its mineral waters. The town of Eger is a watering place, situated on a small stream of the same name. The mineral waters spring in a number of wells or holes dug into the strata on the side of the valley as it slopes down to this stream, and the circumstance to be noticed respecting them is that the amount of overflow from these wells is influenced in a remarkable manner by the pressure of the air as indicated in the barometer. The greater the atmospheric pressure the less is the quantity of water that overflows at the well; and the less that pressure is the greater is the overflow of water. The book contains a plate, in which a graphic view is given of the height of the barometer every day during the months of January and February, 1860, and also of the amount of water which flowed off per minute from the Francis Well on those days, and the correspondence is so striking as to leave no reasonable doubt about the flow of water being influenced, and, as it were, absolutely regulated by the atmospheric pressure. Wet or dry weather does not at all affect the amount of overflow in the well in question. The writer of the paper made a series of experiments on a neighbouring fresh-water spring used for domestic purposes, in order to ascertain whether springs of that kind were at all influenced by the pressure of the air, but he found that the state of the barometer did not exhibit any correspondence with the amount of overflow from the fresh-water spring, which was, like springs of that kind in other localities, dependant upon the ordinary meteorological influences of wet or dry weather for the quantity of water which it discharged. The

mineral spring, on the other hand, was not at all affected, summer or winter, by the amount of rain or snow which fell in the district around, thus rendering it probable that the source of its water is at a great distance, or at a very considerable depth beneath the surface. A glance at the geological map of Europe informs us that the district where these springs exist has been very much disturbed by volcanic action. The water is of a similar character to that of Carlsbad. The district is at a great elevation above the sea level, as the barometer ranges between 309 and 324 Paris lines, or between 27·86 and 28·75 inches (English). Another remarkable circumstance is mentioned in the paper. The author describes the ground where these springs rise as presenting a gentle inclination. At a depth of 10 or 15 feet below the surface there is a bed of sand, out of which the water seems to issue into the wells that are dug in the strata above. It mounts rapidly at first, giving off a considerable quantity of carbonic acid gas. By degrees the rise becomes slower, till it reaches the surface of the ground, when the overflow is conducted away in small channels down the slope; and the remarkable circumstance now alluded to is that at whatever part of the sloping ground a well is made the water will not rise higher than the surface of the ground, and any attempt, by confining it at the lower part of the slope, to make it rise to the same level as at a higher part, is defeated by the water breaking away into the surrounding strata, and depriving the well at that particular spot of its supply. It would appear that the water in these wells is affected by capillary attraction, or something of that kind, and not by hydrostatic pressure, as in ordinary springs. This conclusion seems to follow both from the last-mentioned fact and from that which has been stated in regard to the inverse ratio that exists between the amount of overflow and the height of the barometrical column.

The Chairman—Near Heaton Norris there is some drift-sand filled with water. Attempts have been made to draw it off to a

level some 70 or 80 feet lower, but it could not be coaxed down. It is attracted and held firmly by the sand, and will not drain off. The railway passes through it, and there are little channels by the side of the rails always full of water. There can be no doubt that water is powerfully attracted by sand and other earthy materials, and that the height to which it will rise will sometimes depend upon the nature of the superficial strata.

The thanks of the meeting were given to Mr. Atkinson for his communication.

ORDINARY MEETING, TUESDAY, MARCH 26th, 1861.

E. W. BINNEY, ESQ., F.R.S., F.G.S., Vice-President, in the Chair.

The Chairman said that at the last meeting something was said about an excursion. In reply to several questions, he stated that near Stockport, at Fogbrook, there was a section which would show the beds of new red sandstone, resting on the coal measures, and the lower part of the middle coal measures. Below Marple aqueduct there used to be a bed of black shale, full of shells (the large *Anthracosia*), crossing the river. The shells appeared to lie in the shale like a bed of mussels on one of our present sea beaches. Another excursion was thought of to Runcorn and Weston Point, to see the foot prints of *Rhynchosaurus*, found in the waterstone. Then there was the Todmorden valley. Near Fogbrook there was as good a section of the valley gravel as could be seen in the valley of the Goyt. There was also a good walk up the valley of the Irwell, where might be seen valley gravel as well as in any place near Manchester. This was one part of the drift upon which he some years ago wrote a paper. He then treated the valley gravel as one

mass, but going up the river Irwell he found there were certainly two, if not three, terraces. In the neighbourhood of Mr. Knowles's colliery, at Agecroft, there was a large peninsula, some thirty feet high, which showed a bed of valley gravel that height. A great deal of till had been swept away by water before the deposition of the fine sand which often capped it. The subject of the drift in valleys was by no means exhausted, but was one which all gentlemen in the neighbourhood of Manchester could investigate. The Irwell valley was for the most part cut out of the till or clay, and into trias and coal measures. At present, near the race course, the bed of the river kept shifting, and within historic times it had moved away from its former bed a considerable distance. In the old maps a portion marked Broughton was on the Pendleton side, and a portion marked Pendleton on the Broughton side, and it was cutting gradually across. The same was the case at the Salford Crescent and Broughton road.

Mr. Atkinson—The till or clay in the neighbourhood of Thelwall has been channelled and very curiously scooped-out to various depths, and fine sand deposited.

The Chairman—There is a nice section of drift now exposed at the Stockport station. Sand has been general, but a great deal of it has been swept away. You see it as you go towards Levenshulme; between Manchester and Pendleton, after you get beyond Windsor Bridge, and as you reach the church, you get on the sand.

Mr. Atkinson—Are there in existence any deposits of till upon the sand?

The Chairman—Yes; the knolls at Kersal Moor and other places are chiefly composed of sand, but they are capped with deposits of till. At Stockport station you can see a bed of till in the sand. I would suggest that if any gentleman can get a section of drift it would be very desirable he should bring it here.

The cutting of a road or railway, the sinking of a well, would afford the opportunity. It is only by these means that we can get a knowledge of the theory of drift. If no one has any more observations to make, I will call on Mr. John Taylor, jun. to read his paper on the Geology of Castleton.

Geology of Castleton.

As this was the place of my first geologising on the mountain limestone, some years ago, and a neighbourhood that I have frequently visited since for the same purpose, perhaps I may be allowed to give a few of the observations I have made. Whilst it is a locality interesting to the botanist and naturalist, it is peculiarly so to the geologist, from the abundance of the organic remains, and the various forms of crystallization to be met with. In the recently published map of Reynolds, the mountain limestone is represented as extending from several miles beyond Glossop on the north, having Mellor upon it on the east, and Gillothay on the west. This, however, is incorrect, for the first place that we meet with the limestone in going from Manchester, through Chapel-en-le-Frith, to Castleton, is about two miles from the latter town, near the Buxton road. The walls along the road side from Chapel-en-le-Frith, are, as usual, a first-rate index to the geology of their vicinity. At first they are wholly composed of gritstone, then of limestone fragments mingled with it, and near the junction of the strata we find them composed of limestone altogether. When we do come upon the limestone, we see it stretching away in the direction of Buxton, and as we approach Castleton, it lies upon our right hand, whilst the rocks of which Mam Tor is composed lie upon the left hand side of the road. Trecliff, the first place where we meet with the limestone, is a hill about 600 feet in height: the dip of the limestone which composes it is in a direction N.N.E., having an intensity of about 25°. It is in this hill that the Blue John mines are situated. This mineral (fluate of lime) coloured by the oxide of manganese, lies in pipe veins, having the same inclination as the

rocks in which they lie. It often occurs in nodules, having a radiated structure. There are several of these veins, on the Winnats side. There is one found in which the mineral lies in a sort of clayey stratum, and in another it is imbedded in the nodule state in a mass of indurated debris. The whole of the limestone rocks in this neighbourhood are apparently quite hollowed, through the channeling of running water. In some of the caverns, and worked out mines, which are not usually shown to visitors, the most beautiful crystallizations of fluor spar, varying in colour from transparency to rose, blue, violet, and other colours. Calc spar, especially of the dog tooth form, and Selenite are to be met with. In the Odin mine a carbonate of lime is found quite of a transparent crystallization, and which has the property of double refraction like the Iceland spar. That singular mineral, Slickensides, is also found there, as well as the carbonate of Barytes (Witherite). The characteristic fossils of the mountain limestone are very abundant in this neighbourhood. The richest locality is in the Trecliff, about a hundred yards below the Blue John caverns. The geologist who from time to time may geologise along this hill side, cannot but be struck by the varying forms of fossils which the different beds present. The lower beds of the limestone contain great quantities of Trilobites, of the genus *Phillipsia*, of as large a size, perhaps as any met with in this formation. Heads, carapaces, &c., are very frequently met with but they are seldom found whole. Just as we should have expected from knowing that the family of Trilobites died out with the mountain limestone, as we continue our researches higher up in the beds, we soon find them becoming less frequent, and of a smaller size, and in the upper beds it is very rarely indeed that a single specimen can be met with at all. A little higher up than the beds containing the Trilobites, there occurs another peculiarly rich in Zoophytes, especially of the genus *Retepora*. Of course numerous other fossil remains are to be met with in these beds; but I am speaking at present of the characteristic fossils (if I may use the term) of the beds in question. Above

the last mentioned bed there occurs one of a few feet in thickness, containing scarcely anything but the broken valves of a large *Modiola*. Some of the fragments of this fossil are several inches in length. In the beds which lie above this, *Goniatites* become very abundant, especially the *Goniatites sphericus*, and fossils of the genera *Cirrus*, *Euomphalus*, and *Pleurotomaria*. Very large specimens of the two latter genera are found in the upper beds. It would seem from the prevailing fossils which distinguish these different beds, as though their different forms had from time to time monopolized the ancient seas, so marked does each bed appear by them. All these beds, however, are connected, as though by a huge bracket, by fossils of the *Spirifer* family. The *Spirifer imbricatus* is found in every bed, from the top of the hill to the bottom. Of all the *Spirifers* I ever opened, in order to develop the spiral coil, this species and the *attenuatus* seem to retain it the best. In the limestone of this district, however, I never met with a single head of an *Encrinite* of any genus; although they are so abundant in the mountain limestone of the neighbourhood of Clitheroe: and only once with a single *Pentremite*. On the south side of Castleton the rocks for a great distance seem to be composed of scarcely anything else but the stems of *Encrinites*, to the exclusion of other organic remains. On the road to Tideswell, *Producta* are found in the greatest abundance, and further along the road side, a good section of the rock may be seen, shewing the limestone intercalated with bands of white chert, each about six inches in thickness. Just behind Castleton, a singular chasm occurs, called the Cave Dale; in some places it is not above a few yards in width, and seems, indeed, to be the Winnats repeated in miniature. These chasms are commonly attributed to Plutonic agency. As we look at each side we could almost imagine that if they were brought together they would dovetail into each other. I carefully examined the strata, but there does not seem to be any disturbance beyond the fact of the mere rent occurring. Might not these be effected by the desiccation or sub-crystallization of the rocks subsequent to

their upheaval? In the lower beds of limestone occurring in the Cave Dale, fossils of the genus *Pleurorhynchus*, &c. may be met with. On the top of the hill following the path up this singular fissure, a bed of greenstone, commonly called toadstone, occurs, having crystals of *Augite* imbedded. This bed may be seen on each side of the road, extending for some distance, but it does not seem to have disturbed the strata. The limestone around for a few yards appears more crystalline, and seems to be devoid of fossil remains. Unlike the toadstone found in the neighbourhood of Buxton, which is vesicular, and soon decomposes, this is very compact and hard. Near this toadstone bed there occurs a mass of basalt in the columnar form. It is about four feet high, and some of its sides are 15 inches in width. Thin veins of what is called red jasper, occur in it. Most of the springs and streams that flow through the limestone here possesses petrifying properties; and masses of a porous tufa are to be met with. This tufa contains mosses and small shells incrusted together, and is very commonly met with.

It is rather singular that the *Producta gigantea*, which occurs in such vast quantities in the neighbourhood of Buxton, is seldom met with in this locality at all. Neither have I met with any traces of fish remains.

Mam Tor, which stands on the left hand side of the road going into Castleton, is composed of dark coloured and finely laminated shales, intercalated with bands of fine sandstone, which are very hard from the quantity of iron which they contain. The inclination of these rocks is E.N.E., and the intensity of the dip about 40°. This same rock may be traced through Hope on to Hathersage. Along the brook side on the left below Mam Tor, a good section is displayed where the shales may be seen abutting against the lower limestones. Along the stream below Hope church, another good section of the shale beds is shown; and it is again

displayed along the road from that village to Bradwell. At Hathersage, by the stream side, these shales again crop out. It has been thought that these shale beds were unfossiliferous, but this is not correct, for the lower beds contain fossils in the greatest abundance. In the section along the brook side, which I mentioned first, where the shale abuts against the limestone, the shales are intercalated with bands of gritstone, which appear to be charged with the fragments of comminuted shells and Encrinite stems, the remains of the old beds, which had been denuded away, but they do not contain any fossils of their own. The ironstone bands higher up Mam Tor contain numerous goniatites, very small in size, and quite pyritized. The lower beds of the black shales contain great quantities of *Posidonia*, and occasionally *Aviculo-pectens* and *Goniatites*. along with portions of carbonized vegetable remains. In some places the schist is so charged with Posidonia that they form a thin thread-like seam of limestone from their accumulated remains. Most of these fossils are found lying with their valves open, as though connected by the ligament. This formation evidently belongs to the Yoredale series of Professor Phillips, being exactly like those developed at High Greenwood, Yorkshire, Glossop, and other places, both in their mineral character and fossil remains.

About two miles from Castleton, and a hundred yards from the Buxton road, a limestone quarry has been opened for getting roadstone ; here, again, the shales are seen resting against the limestone, and what is most singular the fossils of the limestone at the junction appear to have become wholly bitumized. Has this been through the percolation of petroleum through the shales? And are the beds of bitumen met with in the Blue John mine owing to the same causes?

On standing upon the top of Trecliff we see the valley stretching away below our feet, and, after running for a few miles, it is split up into two by a hill of about 400 feet in height: this is Eccles

Hill, and is composed of the same material as Mam Tor. Here it would seem as though the left hand valley had been scooped out of the Yoredale rocks; and when we examine the dip of the limestone we see that apparently it has not suffered much from this action, for the inclination of the hill is not much greater than the dip of the beds, consequently it would follow that the whole of this forked valley must have been worn out of the softer rocks.

The drift beds are not found to any great extent in this neighbourhood. The superficial soil in many places barely covers the underlying rock, and in most places it is not above five or six feet in thickness. From the accounts of well-borings in the town, which vary much in their depth, there is what is called a gravel bed, composed of small, angular fragments of limestone and chert. This varies very much, being found from six to ten feet, and below this bed lie the shales. The water supply is obtained from the junction of this gravel bed, and the underlying shales. I have not met with any boulders in the neighbourhood, nor any traces of granitic pebbles whatever. The following are the fossil remains which I have met with in the neighbourhood:—

LIMESTONE.

Cellipora favosa	Koninck's Fossiles Belgiques.	
Retepora membranacea	Phillips Geol. of Yorkshire.	
,, flustriformis	,,	Plentifully.
,, tenuifila	,,	,,
,, pluma	,,	,,
Favosites megastoma	Koninck	
Michelinia favosa	,,	Near Peak Cavern.
Syringipora ramulosa	Phillips	
Cyathophyllum cremulare	,,	
,, basaltiforme	,,	Plentifully.
Caryophylla sexdecimale	Koninck	
,, fasiculata	,,	
Turbinolia fungites	Phillips	
Pentremites conicus	,,	Rare.
Spines of cidaris		,,

Sanguinolaria tumida	Phillips	Plentifully.
„ sulcata	„	Rare.
Corbula senilis	„	
Modiola lingualis	„	Plentifully.
Pleurorhynchus armatus	„	Rare. Cave Dale
Pinna costata	„	
Inoceramus vestustus	„	Very fine.
Pecten dissimilis	„	
Productus martini	„	Plentifully,
„ scoticus	„	
„ aurita	„	Near Bradwell.
„ concinna	„	Plentifully.
„ plicatilis	„	„ (Upper beds)
„ analoga	„	
„ punctata	„	plentifully.
„ spinulosa	„	„
„ fimbriata	„	
„ striatus	Koninck.	
Spirifer cuspidatus	Phillips	Rare. Trecliff.
„ insculpta	„	„
„ distans	„	„ Cave Dale.
„ bisulcatus	Koninck.	
„ striata	Phillips	Pindale.
„ triangulrais	„	
„ attenuata	„	Plentifully.
„ rotundata	„	„
„ linguifer	„	„
„ imbricata	„	„
„ glabra	„	„
„ decorus	„	
„ pinguis	„	
Lingula parallela	„	
Terebratula hastata	„	Plentifully.
„ sacculus	„	„
Rhynconella acuminata	„	„ Fine
„ reniformis	„	„
„ pugnus	„	
„ flexistria	„	
„ pleurodon	„	Plentifully.
„ radialis	„	

Pileopsis trilobus	Phillips		
,, (unfigured)			
Orthis resupinata	,,		
,, umbraculum	Koninck		
Natica amplicata	Phillips		
,, elliptica	,,		
Euomphalus pentangulatus	,,	Plentifully.	
,, catillus	,,	,,	Trecliff.
,, dionysi	,,		
Cirrus acutus	,,		Cave Dale.
,, spiralis	,,		Trecliff.
,, pileopsidus	,,	Plentifully.	(In upper beds.)
Pleurotomaria flammigera	,,		
,, expansa	,,		
,, conica	,,		
,, inconspicua	,,		
,, pyramidalis	Koninck		
,, undulata	Phillips		
,, biserratus	,,		
Turitella tennistria	,,		
Loxonema			
Buccinum imbricatum	,,		Upper beds.
Bellerophon costatus	,,		
,, hiulcus	,,		Rare.
Nautilus cyclostomus	,,		,,
,, ingens	,,		,,
Goniatites striatus	,,		Upper beds.
,, sphericus	,,		,,
,, henslowi	,,		Rare.
,, vittiger	,,		
,, umbilicus	,,		
Orthoceras cinctum	,,		Plentifully.
,, ovale	,,		
,, attenuata	,,		
,, undulatum	,,		
,, gesneri	,,		Rare.
Phillipsia pustula	Koninck		
,, gemmulifera	,,	Plentifully.	(Lower beds.)
,, derbyensis	,,		

SHALES—YORKDALE SERIES.

Aviculo pecten.	Encrinite stems,
Goniatites striatus,	Vegetable remains.
Posidonia,	

The thanks of the Society having been voted to Mr. Taylor for his paper,

The Chairman said Reynolds' map was not the first authority to go by. In the ordnance geological map they put down the mountain limestone more correctly.

Mr. Atkinson—I think chert often seems not to be in bands, but it appears as if the limestone is gradually changed into chert, the carbonate of lime giving place by degrees to silex. Frequently there is no real line of demarcation between the chert and the carbonate of lime; in the same mass of rock, part will be chert and part limestone.

The Chairman—In many limestones you find chert. I have seen it in Silurian, Mountain, Ardwick, and other limestones. The chert when it was not in sufficient quantities to form beds, formed nodules. It is silicious separated from calcareous matter, when both were in a plastic condition.

Mr. Harvey—I suppose, Mr. Taylor, you found masses of bituminous substances, more like India rubber than anything else?

Mr. Taylor—Yes: a great deal.

Mr. Dickinson—There is a great deal of carbonaceous matter in the limestone. You speak, Mr. Taylor, with some doubt as to the formation of these caves; do you think the rock has been rent asunder by some convulsion of nature?

Mr. Taylor—That is the common way of accounting for them, but I do not think it is always correct.

Mr. Dickinson—No; many of these caves are formed by water. I have travelled in a cavern at Ale Burn in Cumberland for many hundred yards. In some places the cave was 20 or 30 feet high, and I think water is the real origin of these caves.

Mr. Taylor—There are some of the cavities and caverns in the old lead works which rob the vein. May it not be caused by the drying of the rocks ?

Mr. Dickinson—What you speak of now is an interesting subject. Where a vein of lead is running through certain beds of limestone, threads, no bigger than a thread of cotton, sometimes go off, and it is frequently found that there are large deposits of lead ore at the side, connected by the threads.

The Chairman—There is no difficulty in saying how these caverns were made. It is by water charged with carbonic acid gas percolating through them and nothing else. There is a far more interesting and difficult subject than this. When you stand on Mam Tor you have a view of Castleton valley. How was that valley excavated?

Mr. Taylor—You know Eccles hill; it is composed of soft shale, and yet it has been preserved.

The Chairman—It would be a place that our members might very usefully visit.

Mr. Atkinson—Mr. Taylor mentioned slickensides as being a mineral. I never understood it to be of that character.

The Chairman—It is not a mineral; it is only a polish.

Mr. Atkinson—As far as I have observed, it seems as if the sides of the vein had been rubbed, and a minute portion of lead or some such mineral had been left upon the smooth surface.

Mr. Dickinson—One part has slipped down or the other part slipped up. It is only one motion.

Mr. Knowles—In the valley you are speaking of is there a stream?

The Chairman—Yes, but it is a very small one, and would require a vast time to excavate the valley. Here is a map made 60 years ago by the late Mr. White Watson, F.L.S., the old geologist of Bakewell. This was his idea of a limestone strata. He represents three beds of limestone and three beds of toadstone. Did it ever occur to you how the valley of Castleton was formed?

Mr. Harvey—Or the valley of Edale?

Mr. Knowles—Are there any signs of the water having been blocked up?

Mr. Harvey—In Edale it is so.

Mr. Taylor—The caverns are sometimes so full of water that they dare not show them to visitors. It has struck me that the vallies of Castleton may have been formed partly by water during the slow rising of the land.

The Chairman said that assuming no sea had run up into the valley, it had only been acted on by its present stream, and it would require a vast period of time to form the valley.

In reply to Mr. Harvey, the Chairman said there would be no

difficulty in making an excursion there. And if the Society went there they should remember the late Mr. Elias Hall, who was one of the earliest of our local geologists, and who made some of the first geological models of the structure of districts. He (the chairman) was in Derbyshire last year, and enquired where the old gentleman was buried, and he found that there was no stone or inscription to mark his last resting place. He thought it would be a laudable thing to put a tombstone over him, and he should be glad to put his name down for a sovereign. He was a very deserving geologist, and a man who worked very hard for 60 or 70 years. He was one of the teachers of Professor Sedgwick, who had said that some of his first lessons in geology were from Elias Hall.

Mr. Atkinson said there are a good many maps and sections of Mr. Elias Hall's on sale at Mr. John Heywood's, at moderate prices, and if the members wish to obtain them, perhaps they had better take means to do so before they are all sold. Though not equal to several more modern ones, these maps are of considerable value, as being made after many years' careful observation in the tract of country to which they relate.

The Chairman said it was not fair to compare Mr. Hall's maps, done many years ago, with those done by the geological survey; but he should like to see something over his grave to show that he was not forgotten.

After some further conversation, the proceedings closed.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 6.] [Session 1860-61.

ORDINARY MEETING, TUESDAY, APRIL 30th, 1861.

JOSEPH DICKINSON, ESQ., F.G.S., Vice-President, in the Chair.

Mr. Whitehead produced and explained the model of a safety apparatus to prevent accidents from overwinding in mines. If the man at the engine attended properly to his duty the apparatus did not act, and there was no need of it. The principle was the application of a steam brake, which could also be worked as a foot brake.

The Chairman—Some of you no doubt recollect that two years ago Mr. Whitehead submitted a model of an apparatus for preventing accidents from overwinding to this society. It was then suggested that it would have been better to arrest the motion before it arrived at the disconnecting point, since, if the disseverance was effected suddenly, the force of the ascending weight would be sufficient to throw it over the pulley. That remark set Mr. Whitehead a-thinking how the suggested difficulty could be obviated; and

shortly afterwards he told me he had made an improvement upon his model, by disconnecting the steam also. I think his efforts, as shown in this model, have resulted in his producing an apparatus which not only shuts off the steam, but also applies the brake should the engineman omit to stop his engine at the proper time. I am sure we are all much indebted to Mr. Whitehead for the trouble he has taken in this important subject, and the more so as what he has effected has been done out of a pure love of improvement, for he has no patent right. The model is a beautiful one.

Mr. Binney—I have much pleasure in proposing a vote of thanks to Mr. Whitehead. I am sure we shall all feel greatly obliged to gentlemen like Mr. Whitehead who will devote their time and attention to devising methods for preventing the accidents which occur in mining operations. If we had more gentlemen like Mr. Whitehead who could give their persevering attention to these subjects without seeking for patents, we should get on much faster than we do in the march of improvement.

Mr. A. Knowles seconded the vote of thanks, which was carried unanimously.

On the Security of the Davy-Lamp.

Mr. Binney—There has been a great deal of discussion about the explosion of safety-lamps. I see that letters have appeared in the *Mining Journal* and the *Colliery Guardian* stating that safety-lamps of the most perfect description have been exploded by fire-damp, and there is no denying the fact. I think the last time I mentioned this subject Mr. Livesey gave an instance, which was a pretty conclusive one, where a lamp had been exploded.

The Chairman—But he was not able to tell us whether the lamp in that instance was in a perfect state. He could not tell whether the lamp had a hoop at the bottom of the gauze. We have seen instances of explosion where the lamp has not been in a perfect state, but I have not had a case, as far as my experience goes, where a safety-lamp, in good order, has exploded from fire-damp.

Mr. Binney—In the majority of these cases no man is left to tell the tale.

Mr. Wynne—I was not present when the statements were made by Mr. Livesey, but, from reading it in your report, I was not at all satisfied with the instance there given as being any guide for forming a judgment as to the security or insecurity of safety-lamps, because the very act of falling might injure the lamp, and it might then be insecure, though it stood the test previously. Or a wire might have struck into it. I do not think the fact of a lamp being dropped and then exploded, is any proof of the explosion of a lamp in a perfect state. I have never seen anywhere that a safety-lamp is not safe to go into fire-damp with.

Mr. Binney—This is the question—"whether Davy-lamps will explode?" Davy-lamps are not always hung from the roof; they are often left on the floor, and knocked about. I hold, Mr. Wynne, that with a Davy-lamp, yourself, or any gentleman well acquainted with such lamps, might go into any atmosphere; but we do not expect all colliers to be endowed with the caution or to possess the experience you have; nor do we expect all colliers to be acquainted with the dangers of the lamp, and how it ought to be used. I hold that lamps perfectly safe with inspectors, who know how to use them, ought not to be given to ignorant workmen as instruments which are perfectly safe. It is a very dangerous experiment to make. Look at the coal dust and oil with which they become fouled, and consider how very frequently lamps get knocked over.

Mr. Wynne—I do not think that that tells against the safety of the Davy, because anything of the kind is liable to derangement. But I should be very sorry to hold out that mines could be worked safely with Davy-lamps unless there was proper precaution as to ventilation; for all mines ought to be ventilated. I do not think the discussion that is going on can at all tell against the Davy-lamp; but it may have the effect of increasing the ventilation of mines.

Mr. Binney—All I want to put before the public is, that to send a man into a mine with fire-damp, merely with the protection of a Davy-lamp, is a dangerous and a wicked thing.

The Chairman—Unquestionably so.

Mr. Binney—I say that the Davy-lamp is a great safeguard, and with the best of ventilation we should still use the lamp as an extra help. I do not mean to say that the Davy-lamp should be discontinued, but that we have no right to rely upon it under all circumstances.

Mr. Wynne—So far, I quite agree with you; and what I should like to see in mines is good ventilation and good discipline. Every underlooker ought to be as careful as our chairman, or perhaps more so, because he is daily and hourly exposed; and if there were careful men compelled to do their duty, particularly at the change of shifts, the Davy-lamp would meet every requirement.

Mr. Ralph Fletcher—I think we are all agreed that the Davy-lamp is not theoretically perfect, but that it is a great help.

The Chairman — And that it should only be relied upon as a means of testing for fire-damp, for which it is a perfect and safe means; and that it should be used as a means of preventing

explosions in case fire-damp should exist. But that the Davy is unsafe under ordinary circumstances, is what I cannot agree to.

Mr. Fletcher—If I understand the correspondence referred to, that is not the question.

Mr. Binney—The issue is—"Can a Davy-lamp of the standard mesh be exploded under any circumstances?" I say it is an admirable instrument, but Sir H. Davy himself, if here, would say that it could be. The South Shields people exploded it.

The Chairman—You can explode it with house gas.

Mr. A. Knowles—I think the experiments made by Mr. Nicholas Wood, are conclusive in proving that the Davy-lamp will not fire gas in anything like an ordinary current of air, if the lamp is in good order.

Mr. Binney—In a case of life and death you ought to have no doubt. If you err it ought to be on the safe side.

Mr. Knowles—There are mines where it is necessary to carry on operations in the vicinity of old workings with safety-lamps; but I have known mines which sometimes have a great deal of fire-damp, and at other times are so perfectly free, that it would be absurd to require the men to work with lamps.

Mr. Farrimond thought lamps should only be used in mines of great depth, which are liable to sudden outbursts of gas. They ought not to be used at all to supersede ventilation. He considered lamps unsafe when a great quantity of dust was flying about in the workings.

Mr. Binney—I never like to see a mixture of safety-lamps and

candles, because in a mine which has been perfectly safe, a change of atmospheric pressure, or a fall of the roof in some part of the workings, may foul the mine directly. Wherever gas has been found I consider that safety-lamps ought to be used there. When I say that a safety-lamp is not safe under all circumstances, I do not wish that the safety-lamp should be done away with, far from it; but the mixture of lamps with open candles is very dangerous.

The Chairman—It is universally condemned, but it is very commonly practised.

Mr. Binney—A man sometimes goes to work when the mine is perfectly clear, and on returning along the workings he finds gas has escaped from a fall of roof, and he is burnt to death in passing it.

The Chairman—There is no doubt that in many cases the gas has gone over closed lamps, and fired at an open one.

Mr. Wynne—I look more to the safety of mines in having a good man in every mine—a man to look over the mine, and pronounce whether this part is safe, or that part unsafe. This man should be in the mine every day, and he would be the best judge whether lamps or naked lights should be used. If we could insure such a man in every mine, he would take care there was due ventilation, and that the air ways were all large enough.

Mr. Knowles—I think lamps should only be used where there is no doubt as to the danger. Whether or not there is danger should not be left to supposition. That ought to be settled by some competent person. Many mines make fire-damp during the time the straight work is being driven, and, when that is finished, get drained of gas and may then be worked safely with open lights. Before compelling the men to work a coal-mine by the use of safety-lamps,

it should be ascertained to be dangerous; because it is a great hardship to a collier to make him work with a lamp which gives worse light and more trouble in the mine than a candle; besides the trouble he has in waiting for his lamp in the morning, and waiting again in the evening to give it in. The men should be saved as much trouble as possible.

The Chairman—But where a man has been in the habit of working with a lamp, such is the force of habit, that if he goes into a mine where candles are used, he will still stick to his lamp. I myself prefer a lamp, as being less troublesome than a candle, and take it though naked candles may be around me.

Mr. Knowles—As a rule the dust in a mine is against the use of the safety-lamp. I have seen places where it has given a great deal of trouble to keep the dust from them.

The Chairman—As to whether the safety-lamp is safe under ordinary circumstances, I think the Davy-lamp answers all the purposes that could be expected of it, and, as a means of testing for fire-damp, is a perfectly safe and efficacious instrument. With it you can tell to a certainty whether you have fire-damp in the mine or not, and you can do that with safety. It possesses strength, or should be made so strong, that it may stand a fall at least once a day, or bear a fall on the ground. The Davy-lamp is subjected to all these tests, and is still found to be in a safe state. Recently there has been a great step taken in looking after these safety-lamps. Formerly the practice was to let a man go into the mine with his own lamp in whatever state it might be. I have seen some with picker holes in them large enough to pass a pencil through. I have seen a manager with his gauze without a hoop; and a fireman's lamp with a gauze of only 256 meshes to an inch, instead of 784. But in the absence of these and other defects, the safety-lamp will stand all ordinary trials, and will also bear the extra test of a fall at least once a day. With an examination of lamps

once a day, I think we have arrived as nearly to the safe working of a mine as we can be expected to do. To distrust the security of the lamp would make persons nervous in testing for fire-damp. As it is, it takes a practised hand not to flinch, but draw the lamp steadily away when it suddenly flashes full of flame.

Mr. Binney—Sometimes the lamps are placed on the tail-end of a waggon. They might therefore have two or three falls.

Mr. Binney then read his paper, prefacing it with these remarks: At the last meeting something was said about Elias Hall. At the time of his death I sent a short sketch of his life to a neighbouring journal, and that sketch, with slight variations, is what I now wish to read to this meeting.

The Late Mr. Elias Hall, the Geologist.

This venerable man of science, so well known in Manchester, died at Castleton, the place of his birth, on Friday the 30th day of December, 1853, aged 89 years. For a month previous to his death he had been confined to his bed, and during the year preceding his friends had considered that he was gradually failing. Mr. Hall had laboured in geology for upwards of 70 years. It is full that time since he accompanied the celebrated French naturalist, M. Faujas de St. Fond, and showed him the wonders of Peak Cavern, at Castleton. He afterwards became acquainted with Dr. William Smith, the father of English geology, and was long the fellow-labourer and friend of Farey, the distinguished author of the "Geology and Agriculture of Derbyshire." Mr. Farey, at page 10 of the preface to his second volume of the work referred to (published in 1813), thus alludes to Mr. Hall:—

"Among those gentlemen who have particularly aided my pursuits and favoured the views of the Board of Agriculture in revising and examining the numerous facts stated in my first volume respecting the stratification and minerals of the county, and

in candidly pointing out the errors so detected therein, I beg to mention here Mr. Elias Hall, fossilist and petrifaction-worker, of Castleton, who, after revising my mineral observations with great labour, on all the great limestone tract north of Winster, and in some of the adjoining shale and grit tracts, has completed several exact models of this district, which exhibit the face of the country, the stratification, mineral veins, faults, &c. in a very natural and perfect manner."

Mr. Hall not only made a geological model, coloured stratigraphically, of the Peak of Derbyshire, but also one of part of the lake district of Cumberland and Westmoreland. Two of these models were purchased by the trustees of the British Museum, at the instance of the late Sir Joseph Banks, the then President of the Royal Society, a warm patron of Mr. Hall's, and they are now to be seen in the geological gallery of the Museum. Although executed 40 years ago, when geology was scarcely known as a science, and the superposition of strata but little understood, they show great industry and ingenuity, and must have contributed much to promote a knowledge of the districts represented. They are some of the earliest models of portions of the earth's surface, in which the different strata are shown by various colours, that the writer of this notice is acquainted with. On their first appearance they were but little understood by the learned of those days, as is evident from what Mr. Farey says at page 8 of vol. 3 of his work on Derbyshire.

"I am sorry to add that the very meritorious exertions of my friend, Mr. Elias Hall, have just met a similar fate through the same party. [Mr. Farey was alluding to some unfair conduct towards himself by certain persons in London.] No sooner was one of his models shown before several of its leaders, than, without waiting to examine a single particle of its laborious details, advantage was taken of an injudicious use of rather too glaring colours in Mr. Hall's first attempt, to raise a laugh by the far-

fetched and contemptible joke, that 'a tray of guts and garbage in a fishmonger and poulterer's shop,' rather than anything else was called to the mind by viewing this elaborate model of the stratified hills and dales of a tract of country! Such was the conduct of the heads of a Geognostic Society, and such the reward of meritorious labours out of its pale; and my friend remains, and is likely to do so, a considerable loser by what he has done."

However, Mr. Hall was not the man to be laughed down or disheartened by a bad joke. He was made of much tougher materials. A model of the neighbourhood of Manchester, by Mr. Hall, is now in the Museum of the Natural History Society, Peter-street. His next work was a mineral and geological map of the coal-field of Lancashire, with parts of Yorkshire, Derbyshire, and Cheshire. This was an undertaking of enormous labour, and must have occupied Mr. Hall many years. The difficulties to be encountered in tracing the coal-seams of this extensive district, dislocated and fractured as they are, ever varying in thickness and quality, and covered up sometimes by hundreds of feet of drift deposits, are only to be estimated by those who have attempted to investigate them in a single parish. To say that he succeeded in making a correct geological map of so much difficult ground would not be true; for had he been spared twice his long life he could not have done it, nor could any other living man. His plan of dividing the different seams by their accompanying sandstone rocks, and laying the latter down on his map in different colours, is a most convenient one. His bold and vigorous mind has chalked out the broad outlines, and it remains for young and active geologists, with all the advantages of modern science, patiently to correct and fill up the details. Would that the father of geology in Lancashire, as Mr. Hall may be justly termed, had left some pupils endowed with a tithe of his dogged industry, his indomitable perseverance, and his firm love of truth. After publishing his large map, Mr. Hall brought out a coloured section of

the strata from the Irish sea, through Lancashire, Derbyshire, Nottinghamshire, and Lincolnshire, to the German ocean. In 1836 he published an introduction or key to his map, and, with the assistance of the late Mr. Francis Looney, F.G.S., gave a list of the organic remains found in the different beds. During the latter years of his life he was engaged on a geological map of the central part of England, and up to a few months of his death he travelled about the country in search of information, with all the zeal and energy of a young man. He was for many years afflicted with a lameness which would have kept at home many men a third of his age, but, with this exception, he was a wonderfully fine, hale, and hearty man, in a "green old age," full of good spirits, of a most cheerful and social disposition, and ever ready to afford to his fellow men what information he possessed. About two years prior to his death the writer of this notice dined with Mr. Hall at a party of self-educated men of science, in Manchester, and then he looked as likely for prolonged life as any of the company present. He said that he ate, drank, and slept as well as he ever did in his life. During the meeting he sang four songs, one of which was a most humorous old ditty, entitled "Ups and downs."

During the last years of his life, visitors to Castleton might see, in the little curiosity shop opposite to the hotel, the venerable owner—a silver-haired old man—intently poring over his map, and, with a pair of rusty compasses, busily engaged in attempting to lay down some of the ancient strata of the globe. But now both Mr. Hall and his labours appear to have been forgotten in Castleton, for not even a stone marks his last resting place.

Mr. Binney—Since the last meeting, Mr. Chairman, I have received several small sums, one from Professor Tennant, of London, towards the erection of a monument to Mr. Hall. A friend of mine told me that there was a tablet in Castleton Church

to the memory of the late Mr. Mawe, the mineralogist; and he should like to put up a tablet to Mr. Hall in the Church if it could be managed.*

The Chairman—I think we are very much indebted to Mr. Binney. Such an old Geologist should have had a notice long before this; but many of you will remember that this society was for a considerable period in a dormant state, until three or four years ago, and that many of the gentlemen who are now members were not members then; and though all cannot be expected to contribute towards a tombstone, yet it should be remembered that the society is never old, though some of its members may be. It seems a very worthy movement to be made by the society.

Mr. Taylor, Jun.—Within the last fortnight some bones have been found in one of the Peak caverns, which is not usually shown to visitors. Mr. Hall, Solicitor of Castleton, has taken the bones to show to some Geologists in London.

Mr. Binney—It is very desirable that we should get them here. We have as good a claim to them as the London Geologists.

Mr. Taylor, Jun.—Between Castleton and Sheffield there is a cave very productive of bones.

Mr. Binney—It is very desirable we should have a sight of the bones that have been found, and a description of these caverns.

The Chairman—We ought to know whether the cavern has been previously explored or not, else we may be liable to be imposed upon.

* Since this paper was read, it has been found impossible to put up the tablet in the Church.

Mr. Binney then read a second paper, entitled "The Drift Deposits found about Llandudno."

On the Drift Deposits found about Llandudno.

Professor Ramsay, in a paper on the superficial accumulations and surface markings of North Wales,* has fully described the great elevation that some of the drift deposits reach in North Wales, attaining in some instances a height of 2,500 feet above the level of the sea. Little information, however, has been given to the public on the drift deposits lying at lower levels, near the sea, and therefore the following few remarks may not prove unacceptable to the society:—

Being at Conway during the past summer, the bank on the east side of the river there, on the road leading to Llandudno, attracted my attention. It is on the right hand side of the road, and is probably about 30 feet above the waters of the Conway. The following is a section of the deposits in the descending order:—

Finish sandy gravel, composed chiefly of rounded and partly-rounded pebbles, of greenstone, slate and silurian rocks, containing shells of the *Littorina littorea* and *Mytilus edulis*	4 feet.
Brownish coloured till, containing angular, rounded, and partly-rounded pebbles, similar in kind to those in the last deposit	25 „

The till might probably be much thicker, as its lowest part could not be seen.

The till resembles the same deposit found on the west coast of Lancashire, at Blackpool, and described by me in a paper published in vol. X, new series of the Memoirs of the Literary and Philosophical Society of Manchester. No entire fossil shells were observed in it, but from the appearance of fragments of a univalve resembling the *Turritella terebra*, they will probably be met with on more diligent search being made.

* Vol. viii. of the Quarterly Journal of the Geological Society of London.

The flat district lying near the beach of Conway bay is covered with sand dunes until you approach Llandudno, near which place, in the marsh ground, a bed of silty clay is exposed five or six feet deep in the ditches. This is free from pebbles, and looks like ordinary sea silt. Under it the same brown till near the east bank of the Conway before described is met with. This is well shewn in the brick yard on the right hand side of the turnpike road leading from Llandudno to Conway, about half a mile from the former place. About ten feet of till is exposed, containing angular and rounded pebbles, chiefly consisting of slates, silurians, greenstones, a few mountain-limestones, some of them being scored and striated.

The deposit of brown till appears to underlie the whole of the country lying between the Great and Little Ormes Heads, and little evidence can be obtained of its entire thickness, but it must be considerable, as it has been proved to be 30 feet without the underlying rock having been reached. At the side of the beach at Llandudno, near the steps going down to the shore, and not far from the baths, is the following section of beds in the descending order:—

	Feet.	Inches.
1 Brown soil	1	2
2 Limestone and slate gravel well-rounded	0	2
3 Angular pieces of mountain-limestone in a clay cement	0	10
4 Sandy clay, containing a few slate and mountain-limestone rocks, some rounded and some angular	1	2
5 Sandy bed, containing rounded pebbles of slates and greenstones, and quartz, with scarcely any mountain-limestones	0	6
6 Brown till, with slate, silurian, and mountain limestone rocks, mostly angular, very few mountain-limestones containing shells of *Turritella terebra*, exposed only 3 or 4 feet, but proved, I was informed, to be upwards of ...	30	0

The first three deposits are of very recent origin, the angular pieces of limestone mixed with clay, No. 3, having been brought from the workings of the old copper mine, to raise the beach; No. 2 being a layer of shingle, washed over No. 3 on the occasion of a very high tide, and No. 1 being brown soil brought for the purpose of forming the promenade.

Immediately below the baths is seen a piece of brown mountain-limestone *in situ*, scored and polished, probably by the action of ice.

At the foot of the Great Ormes Head on the east side, a deposit of blackish brown clay, containing angular pieces of mountain-limestone is found. It is seen near the old copper-mine shaft in Mostyn Street, and can be traced by both the carriage roads from Mostyn Street up to Primrose Cottages, 162 feet above mid-tide, and contains an abundance of shells of the *Littorina littorea*, *Patella vulgaris* and *mytilus edulis*. The clay is seen up to Tyn y Coed 100 feet higher. About 100 feet higher still, at a point some 80 yards below the point where the two carriage roads diverge, the one going to St. Tudno and the other to the Telegraph Station, at an elevation of 400 feet from the level of the sea is a singular deposit of shingle.

The road is cut through this shingle, which is about 2 feet in thickness, and lies on the mountain-limestone. It is composed of a fine sandy shingle consisting of small slate and silurian gravel, very similar to that now found on the beach below, mixed with larger pebbles of well-rounded white quartz and chert, and resting on still larger pieces of limestone, which are angular. The shingle at first sight appeared to me to have been brought up the hill for the purpose of repairing the old road before it had been worn down so low, so much did it resemble that now found on the beach, but the rounded pebbles of white quartz and chert of the size of a pigeon's egg, and the fact of my having tracked the shells all the

way up that hill from the sea beach, convinced me that it was a natural deposit. In it occur *Littorina littorea*, *Patella vulgaris*, *mytilus edulis* and *ostrea edulis*.

My time would not allow me to examine the higher part of the head up to the Telegraph Station, to see if the deposits extended up to that height, or whether they where confined to the hollow on the east side of the Head, in which the carriage road goes. This is a sheltered place, and would afford a *habitat* for the shells, better suited for them than the more exposed parts of the Head.

The fossils are similar to those found in the adjoining sea, and clearly prove that the Great Ormes Head has been elevated at least 400 feet above the sea at very modern geological epoch, and long after the formation of brown till or boulder clay now found lying in the valley between the Great and Little Ormes Head. As the Head rose from the sea it gradually elevated with it the banks of shells now found on its sides, the living shells holding their position between high and low water, although the land was constantly going up.

It was proposed by the Rev. George Perkins, M.A., seconded by Ralph Fletcher, Esq., M.A., and resolved—"That the thanks of this meeting be given to Mr. Binney for his two interesting papers."

Mr. Binney then explained by a diagram how the drift was situated on the Great Ormes Head.

Mr. Taylor—If I remember rightly some shells have been found in the drift in the neighbourhood of Manchester.

Mr. Binney—There are plenty of shells near Bowdon; at Haigh and Wigan; and they have been found at Tintwisle. There is no doubt about shells being found in the till of Lancashire.

The Chairman—Have you noticed near the Little Orme's Head the sand used for making glass? What do you think of that?

Mr. Binney—I don't know whether we should go to that; it is rather foreign to the drift.

The Chairman—But it has been mistaken for drift.

Mr. Binney—It is a subject I have considered for the last ten or twelve years; and the one named is not an isolated case. I have seen sand in holes in the limestone, and the sand is generally a little finer in grain as you go upwards. I have seen it in Staffordshire and other places.

Rev. G. Perkins—Have you any theory how it got into this position?

Mr. Binney—No.

The Chairman—I dare say some of you may have seen the hematite formation at Ulverstone which occurs in the limestone. It is like the top of an immense mineral vein, and the hematite is found in the course of the vein. This sand lies in a manner very similar to the hematite of Dalton and Lindal.

Mr. Binney—They have got to the bottom there on the limestone floor.

The Chairman—And so have they with the hematites, but they open out again. How the limestone here becomes possessed of the property of causing the iron ore to be deposited at particular points] I know not, but it does possess such a property; and this sand has been deposited by the same law as the hematite I have no doubt.

Mr. Binney—With regard to the iron ore, I have written a paper on the Ulverstone ores, which seemed to me to lie in eroded valleys, but I believe that many of these do occur in veins. A great many more of them are filled-up valleys. Valleys have been eroded out of the limestone, and then, at the period of the Permian deposits, this great mass of iron must have come into the waters of the ocean, and flowed into the valleys. As you go to the north they are regularly stratified, like beds of coal. It is very clear the ore has been deposited like any other sedimentary deposit.

The Chairman—In the forest of Dean we find hematite lying in churns, and running parallel with the bed of the limestone. At Llantrissent, where recent discoveries have been made, the deposits are similar to those at Ulverstone. The formation of hematite is a very interesting subject; I hope some of our members will favour us with a paper upon it.

This terminated the business of the meeting.

ORDINARY MEETING, TUESDAY, MAY 28th, 1861.

E. W. BINNEY, ESQ., F.R.S., F.G.S., Vice-President, in the Chair.

The Chairman said he had to announce a donation to the society of a book entitled "Flint Implements in Drift discovered on the Continent, and communicated to the Society of Antiquaries," by John Evans, F.A.S., F.G.S.

On the motion of Mr. Atkinson, seconded by Mr. Readwin, a vote of thanks was passed to Mr. Evans for the donation.

It was announced that Mr. Edward Lacey, of the Buxton Lime Works, Whaley Bridge; and Mr. George Charlton, of Dunkirk Colliery, Dukinfield, had been elected members of the society.

The Chairman said he would read a communication he had received on the subject of safety-lamps. Some time since there was a discussion here upon these lamps, as to whether, as they are at present used, they ever caused explosions by firing the gas outside. I stated that safety-lamps had exploded as at present used—safety-lamps perfect as to mesh, diameter of the wire, and in every other respect; and Mr. Livesey gave an instance of one which exploded. Certainly the man had lifted it up and allowed it to fall, and it then exploded. I have heard the statement I made questioned, but I adhere to everything I then said. If I err I do so on the safe side; and to err on the safe side I think the best course. I make these remarks that I may introduce a letter which Mr. Joseph Goodwin, of Hyde, has been so good as to write to me, and which I will read to the society:—

Hyde and Haughton Collieries,
Manchester, May 23rd, 1861.

E. W. Binney, Esq., F.R.S. &c.

Dear Sir,

From the great interest you have long evinced in everything that has for its object the improvement of the ventilation of coal-mines, and thereby giving increased safety to the poor miner, and additional security to the capitalist, and from the fact that in prosecuting this object you have spared neither pains nor expense, I do not hesitate to write to you upon this subject, having no fear of being considered presumptuous.

I see from the discussion of the Manchester Geological Society, on "Mr. P. H. Holland's Sealed Lock for Safety-Lamps" that you entertain the opinion

that a proper Davy-lamp can explode in gas. In this opinion I beg to differ with you, and shall state my reasons for so doing. I fully believe that we have not a well-authenticated case of fire-damp exploding through a safety-lamp of 26 or 28 meshes to the inch. If a lamp gauze is covered with oil, or a defect exists in the lamp, so as to allow it to lose its oil, it is not fit to be worked by; and where there is any discipline no defective lamp will be allowed to go out of the lamp-house for such purpose, and ought not therefore to be considered as a fair test. I have myself worked by the Davy-lamp on many occasions when the gauze and standards have been red-hot, and have been obliged to take hold of the lamp bottom with my cap, in removing it, to avoid being burned; and when the lamp was suffered to go cold, the gauze and standards have exhibited the colour of tempered steel; and yet the lamp has remained perfect. I have also conducted many experiments for the purpose of satisfying myself whether a sharp jerk of the hand containing the lamp would be sufficient to explode gas, but I have never been able to do so by moving the hand in the quickest manner I could. On one occasion I saw a most reckless act committed by a collier, at Norbury Colliery, which fully confirms my conviction of the impossibility of being able to explode carburetted hydrogen through a perfect Davy-lamp; this collier and others, before commencing work in the morning, had been wafting the gas out of a level where it had accumulated in the night, and had placed their lamp a few yards beyond the thrill that formed the air course, the gas had overcome the air, and when we noticed the lamp it was quite full of burning gas, and one of the colliers took the lamp from where it stood and threw it many yards; the space through which the lamp passed when thrown was completely filled with gas, yet it did not cause an explosion. It is nearly twenty years since the circumstance occurred, but the effect produced upon my mind was such that I retain a vivid recollection of it. There are two men now living who can bear testimony to the whole statement.

The experiments conducted by me have been principally in thrills or narrow bays, where a good current of air has been passing the bottom, and the danger could not have been great should an explosion have occurred. I need not tell you that the gas is generally found purer or of a more highly explosive nature in those places than elsewhere.* The only danger in my opinion in the use of the Davy-lamp is that of allowing the workmen to work with the lamp when it becomes red-hot, and to remain too long in that state with it; certainly a duty the lamps were never intended to perform. Of course I except the risk or danger of taking lamp tops off, and the injuries that may arise to the gauze from a fall of

* Dr. Wm. Gregory, in his Chemistry, speaking of the mixture of light carburetted hydrogen and oxygen, which usually goes by the name of fire-damp, says—"If the air is less than six times, or more than fourteen times the volume of the gas, explosion does not take place."—Ed.

the roof, or many other causes, and thus render the lamp of no service. I therefore maintain that the present Davy-lamp answers all purposes for which a lamp ought to be used—that of proving whether gas exists in the workings of a mine prior to commencing operations in the morning, and as often in the day-time as the working-place of a miner has been vacated and comes to be re-entered.

If the present lamp could be made absolutely perfect, or could the electric light be adapted to the use of the miner, so that explosions should thereby be rendered impossible, the evils arising to the workmen from breathing vitiated and poisonous air are unassailed; and unless some corresponding care was taken to ensure perfect ventilation to clear the mine of all the deleterious gases that are generated from decaying vegetable and animal matter, from the combustion of the lights, and the decomposition of pyrites, from the humid or dusty atmosphere of the mine, and many other causes of unhealthiness, independent of the gases usually given off in the working of coal-mines, I should consider it one of the greatest calamities that could befal the coal-miner of this country to make the lamp perfect and to use it exclusively. If you have ever even casually noticed the men that have worked for a few years with the safety-lamp, where it is used exclusively, you will have seen premature old age and decay stamped upon every lineament of the countenance of those who have scarcely arrived at the prime of life; it is no uncommon circumstance for colliers of thirty to be taken for forty-five years of age and upwards. Numbers of lives are no doubt annually sacrificed by this slow process—to say nothing of the great numbers that are hurried to an untimely grave by explosions. This is no exaggerated or overdrawn picture. What then would be the condition of the miner, if the horrors of an explosion and its consequent ruinous effects will not suffice to keep the mine moderately healthy and well ventilated? It is true, the effect might not be so startling as when scores are killed at once, nevertheless, it would be productive of as baneful results, and would be felt as keenly by the capitalist, the miner, and the community at large.

I put my views forth briefly in the early part of the year in the form of a pamphlet, which I anticipated would lead to a discussion of the subject through the press; and I therefore reserved many points for future treatment; but I regret to say that no one has made an attempt of that kind. Not feeling certain that you received my pamphlet, I herewith send you another copy of it, and beg to apologize for the length of this communication.

I am, dear Sir, respectfully yours,

JOSEPH GOODWIN.

P.S.—You are at liberty to make any use of this communication you may feel disposed to do.

The Chairman—I have nothing to find fault with Mr. Goodwin for; he confirms the views I put down in writing some time ago, in a lecture which I delivered at Burnley.* What I stated in that lecture was this:—

"Where gas is met with, no one who knows anything of it will hesitate what to do. He will remove it out of the mine as quickly as he can. When this is done, the Davy or any other lamp should be employed by the workmen, as a precaution against any stoppage in the ventilation, by falls of roof or derangement of air courses, or by the sudden liberation of gas from the roof or other part of a mine.

Lamps are frequently used in the opening of seams of coal, in driving fast places, and when pillars are being robbed or worked back, whilst naked lights are in common use over the greater part of the mine. This dangerous admixture should be openly condemned. The most experienced miner, or the best scientific man, will not be able to guard against the sudden coming of so invisible, intangible, and subtle an enemy as fire-damp; nay, in many cases, will not be able to detect its presence by any of his senses, unless a light is present."

Then I afterwards stated in another part:—

"To my mind, ignorance of the origin and properties of fire-damp is the chief cause of the explosions of fire-damp in mines. This want of knowledge of the subtle enemy they have to deal with is, I fear, alike common to both officers and men. The proverb that 'knowledge is power' is nowhere more applicable than when applied to fire-damp in a coal mine, for no intelligent officer who knows much of that gas, will be long in removing it as soon as it is generated, and also be constantly prepared for its appearance in the mine when it is known to exist, or even where there is a probability of its existence. The mixed use of Davy-lamps and candles in a mine where fire-damp is known to be in any part of the workings or waste, is, to say the least of it, both reckless and dangerous.

A securely locked Davy-lamp, with a shield, is a safe instrument in the hands of a careful man, who knows the principles on which it is constructed. By this I mean that it is invaluable for an intelligent fireman to examine the workings with, before the men are sent into them, and for workmen to use it as a precaution in a well-ventilated mine against accidents in the ventilation; but it should never be used as a substitute for ventilation, and in places so full of gas as to have the gauze full of flame. There is no excuse in the world for working with

* "Popular Lecturer," by Mr. H. Pitman. No. 43.—Manchester; J. Heywood, 170, Deansgate.

lamps full of flame, for any length of time, and if it is persisted in, accidents sooner or later are sure to occur. Often, when in a dead place, lamps are filled with flame, there being too much fire-damp present to make the air explosive, the admittance of a current of air will suddenly dilute the gas to the point of greatest explosion, namely, one of fire-damp and seven of air, and a series of explosions will take place in the lamp. It is then said to be very *sharp* gas, and some practical men think that the mixture contains other gases than fire-damp and air, but all investigations up to this time have failed to detect such gases, and I therefore still think that the sharpness arises from its being at the mixture of greatest explosion.

It is very difficult to pass flame through good standard gauze, even the flame of coal gas containing a considerable amount of olefiant gas, as my experiments now exhibited clearly show; but still flame will pass through gauze saturated with oil and covered with cannel-coal dust.

In cleaning lamps which have had coal dust burnt into a cinder on them, it is very difficult to get it off, and in doing so the gauze is sometimes damaged. Accidents occur frequently from damaged gauze, and too great care cannot be bestowed in examining the gauze before the lamp is used.

* * * * *

In common use throughout the United Kingdom, the lamp is pretty much the same as when it came out of the hands of the inventor. For simplicity, utility, and cheapness, the lamp will, in the opinion of most practical men, be preferred to any yet introduced. The inventor especially cautioned workmen against allowing the gauze cylinder to be heated to dull redness, and moving it against a strong current of air. He saw what we all now know, after 30 years' experience, that the locked Davy-lamp with a good shield was a safe instrument in the hands of a careful man who knew the principles on which it was constructed. It never was his idea that it was to be opened and closed, like the door of a common lantern in the open air—placed on the sloping floor of a mine with dry coal-dust on the outside, and oil spilled on the gauze in the inside—moved swiftly against a strong current of an explosive mixture—placed under a falling mass of coal, so as to be crushed into all kinds of shapes—or, when injured, to have the light extinguished by being blown out;—yet it is well known that the lamp has been subjected to all these varieties of hard usage, and very unreasonably been expected to prove "a safety-lamp."

Those were my remarks, and what I have stated in public I strictly adhere to; and what this gentleman has stated I think

confirms my remarks in nearly every point. It is a subject to which we cannot give too much attention.

Mr. Atkinson—The great danger to be guarded against seems to be lest the men should become possessed with the idea that a lamp is safe, simply because it is a lamp, and not because it is in good order, and properly used. When it is not in good order, it ceases to be a safety-lamp, and men ought to be fully impressed with this important truth.

Mr. A. Knowles—I think Mr. Goodwin is correct as to the injurious effect upon the health of miners produced by working with lamps where there is gas in the pit. I have attended many inquests where I have seen men who have worked with lamps in the presence of fire-damp, and I have noticed that they have all had a cadaverous look, as if their health was materially affected by breathing the noxious gas; and very possibly by working with lamps, they are in the habit of breathing a worse atmosphere than they would do if they had to secure sufficiently good ventilation to enable them to do away with the lamp altogether.

Mr. W. Blackburne—It is your opinion, then, that where safety-lamps are used in the pit, less care is taken in the ventilation of the colliery?

Mr. A. Knowles—I think, as a rule, ventilation has been neglected in consequence of reliance upon the lamp. Men will even sometimes go on working with their lamps full of flame.

Mr. Farrimond—My opinion is that our inspectors, now, won't allow a man to breathe this gas, and when it is discovered it is soon removed. Men sometimes work with their lamps full of fire, but it is never for any length of time. I think many mines in which lamps are used are better ventilated than those in which candles are used. In a good many mines where candles are used there are places in which candles won't burn at all.

Mr. W. Blackburne—Mr. Goodwin has written that letter in consequence of the chairman stating at a previous meeting that an explosion had happened in a colliery by means of a safety-lamp in good order igniting the gas. Mr. Livesey, I think, agreed with him, and mentioned a particular case; I, however, differ in opinion with them, and do not believe any explosion would occur unless the lamp was defective.

The Chairman—It is a matter of evidence that there are cases in which safety-lamps in ordinary usage have exploded. I have given my reasons for saying that the Davy-lamp is nearly the best thing known; but still I won't assert, and have on my mind the responsibility of saying, that a Davy-lamp is safe under circumstances in which it is generally used. I am very glad to hear Mr. Farrimond is of a different opinion from Mr. Knowles, in saying that safety-lamps are not now used when full of flame; but I must think also with Mr. Knowles, that in a great measure lamps are made use of to supersede ventilation; and, as Mr. Goodwin says, men may be killed quietly and lingeringly, but as surely as by explosion. I have often thought that inspectors might do a great deal, but all officers must be careful, and the men must be careful and well-disciplined. Whenever an intelligent collier asks me what he should do when he finds fire, I tell him—"Write a note to the inspector, and tell him to come and look at your place." The inspector cannot go into all mines; but all working men, whenever they see anything wrong, should write to the inspector; and the inspector should hold these letters secret. Thus every man will not only be looking after himself, but also after his fellow-workmen. He will say to himself—"Here is a man next to me whose place is not properly looked after, and if it explodes it will kill me as well as him. I will write for the inspector to look at it." Then if we had inspectors who would go as soon as they heard of any deficiency, we should have proprietors, and officers, and men spurred on, and then we should have as good a system as we could expect to have.

Mr. Readwin said the men in collieries were sometimes very careless. He was in a Welsh colliery the other day, and two men called out to him, but he could not understand them. He bent down, and presently three shots went off close to him.

The Chairman—They are often fond of a joke. I have gone down sometimes to get samples of fire-damp, and I have had difficulty in getting anyone to go into the place. I have seen men working with red-hot lamps. I once heard a lecture in Manchester, and the lecturer asserted that lamps were safer when they were red-hot, and that a red-hot Davy-lamp gave more light, as well as more safety. (Laughter.) I actually heard that, some years ago, in a lecture in this city, and I have a note of it now. I am glad to hear that red-hot lamps are now seldom seen.

The chair having been taken by the Rev. George Perkins,

Mr. Binney read the following paper :—

On Sigillaria and its Roots.

By E. W. Binney, F.R.S., F.G.S.

No part of geology has excited more attention than the study of the valuable coal-fields of England, which have been explored with superior care to any other portion of the earth's surface of similar extent. Whether we view them as the grand *herbaria* of the ancient world, or consider them as the sources of our national greatness, they are alike worthy of attention. On the present occasion an attempt will be made to bring before your notice some of the extraordinary forms of the vegetable kingdom that, countless ages ago, flourished upon the surface of that part of the globe now constituting our coal-fields. But before doing this it will be proper to present you with a general sketch of the chief advantages which England has derived from that most valuable of mineral products, *coal*. It is to this that we owe our vast manufacturing districts

and the numerous population to which they afford subsistence. Coal, as a *fuel*, not only saves from the woodman's axe the beautiful timber trees that adorn our rural scenery, and which in other less favoured countries are consigned to the flames for the purpose of yielding heat, but it supplies us with the giant power of *steam*, that unceasingly works our unrivalled machinery, enables us to annihilate distance on the railway, and, in despite of wind and tide, drives our noble steamers across the trackless ocean. In the hands of the *chemist*, coal supplies us with the brilliant gas that dispels the darkness from our streets; it gives the colouring matter of the gorgeous pinks, blues and greens of the calico printer; it supplies pitch and tar for the preservation of our timber; naptha as a solvent for india-rubber, in the formation of our waterproof fabrics; oils as substitutes for vegetable and animal oils for the purpose of lubricating machinery and burning in lamps; paraffin as a wax for candles, and the various salts of ammonia used in calico printing and other departments of the arts. Latterly alcohol has been obtained from coal; whilst from coal-tar, a substance having the medicinal properties of quinine, as well as being a valuable dye, and also essential oils resembling those obtained from lemons, almonds, pears, &c., and used in scenting soaps and flavouring confectionery, have been extracted. All these last-named useful products are obtained from coal in the manufacture of gas, and were, until lately, thrown away as refuse, and the gas producer had hard work to dispose of them, unless he could turn them into an old abandoned coal-pit.

Strictly speaking, coal cannot be termed a mineral, for it is not composed of inorganic matter. It is vegetable matter chemically changed, and more or less mixed with mineral matter. The bright part of coal, which does not soil the fingers on being touched, shows no more trace of structure than pitch, but the pulverulent, carbonaceous matter, so frequently found in coals, which soils the fingers, is nothing more than charcoal, and, like charcoal, it con-

tains abundant traces of structure. If you were to boil a pitch until it became fluid, and then mix it with crushed c this mass, on cooling, would show something of the app that coal does, the bright part exhibiting no structure, wl dull part, or charcoal, would shew the vessels of the wo which the charcoal was produced.

Time will not permit an exhibition or description of th delicate plants which abound in the roofs of our coal-min even if it did, these specimens, being generally but d leaves and stems, would give but little information. The have been drifted by currents of water to the places where t now found, or they might have grown there. No positive e can be adduced in support of either hypothesis. The case different, however, with regard to some of the larger plant in the coal-measures, and it is to two of them best know public, namely, those hitherto classed under the genera *st* and *sigillaria*, that your attention will now be directed. Bo plants are undoubtedly found upon the places where th grew and flourished, and scarcely a seam of coal, when examined, is destitute of some traces of them.

On Stigmaria.

First, then, with regard to the *Stigmaria*. Probably n plant has excited more discussion among botanists than t *maria*, about which, although the commonest in the whole of plants found in the coal-measures, there was till la greatest uncertainty as to its real nature. In the Lancashi field traces of it may be found in every mine. It abound the floors of the coals generally unmixed with any othe and having the long stringy fibrels formerly considered a but now proved to be rootlets, radiating from the stem directions, and often the rootlets alone are seen without th By careful observation it is also to be found in the upper an portions of most of the seams of coal, often with its

appendages.* It is also more rarely met with in the roofs of coal-mines, and in sandstone rocks. The specimens in the floors are the most numerous, and they are generally found to strike down from the lower part of the coal into the clay underneath; sometimes, when this deposit is a thick one, at a considerable angle, and when it is thin, nearly horizontal. Among the many authors who have written on this plant, probably no one has shown so accurate a knowledge of it as Mr. Steinhaur. In an elaborate paper printed in the first vol. of the new series of the American Philosophical Transactions he describes the most perfect form of the fossil as that of a cylinder, more or less compressed, and generally flatter on one side than the other. Not unfrequently the flattened side turns in so as to form a groove. The surface is marked in quincuncial order, with pustules, or rather depressed areolæ, with a rising in the middle, in the centre of which rising a minute speck is often observable. From different modes and degrees of compression, and probably from different states of the original vegetable, these areolæ assume very different appearances; sometimes presenting indistinct rimæ, like the bark of an aged willow; sometimes, as in the shale impressions, exhibiting little more than a neat sketch of the concentric circles. He was of opinion that the fibrous processes, acini, spines, or whatever else they might be called, were cylindrical, that small fragments of these cylinders showed distinctly a central line of pith, coinciding with the point in the centre of the pustule, and that some of these extended to the length of 20 feet. He also notices the groove of the cylinder being always under, and suggests that the pith has fallen down from the centre; and after further details he concludes

* It has often been stated that *stigmaria* is only found in coal floors. It is not so; for *sigillariæ*, *lepidodendra*, *calamites*, and other common coal-plants are often met with in the roofs of coal-seams and in the upper parts of the beds of the coal. This is fully stated by me in a paper read before the British Association, at the Manchester meeting, in 1842. Of all plants they have contributed most to the formation of coal. In the examination of their structure not only will great light be thrown on physiological botany, but much valuable information will be afforded as to the origin of coal.

" that the stem was a cylindrical stem or root, growing in a direction nearly horizontal in the soft mud at the bottom of fresh water lakes, or seas, without branches, but sending out fibres from all sides. That it was furnished in the centre with a pith of a structure different from the surrounding wood or cellular substance, more dense and distinct at the older end of the plant, and more similar to the external substance towards the termination which continued to shoot. And perhaps that besides this central pith there were longitudinal fibres proceeding through the plant like those of the roots of *pteris aquilina*. With respect to any stem arising from it, if a creeping trunk, we have hardly ground for a supposition."

Messrs. Lindley and Hutton, after noticing at great length Steinhaur's remarks in vol. 1, p. 106, of their *Fossil Flora*, come to the following conclusions—1st, That it was a prostrate land plant, the branches of which radiated regularly from a common centre, and finally became forked. 2nd, That it was a succulent plant. 3rd, That it was a *dicotyledonous* plant. 4th, That the tubercles on the stem are the places from which the leaves have fallen. 5th, That the leaves were succulent and cylindrical. These authors in their introductory chapter of the second vol. of their work, after stating that they had seen two very perfect specimens, found in the roof of the Bensham seam of the Jarrow Colliery, state " that the centre of the plant was a continuous homogeneous cup, or dome, and not the remains of the arms squeezed into a single mass, as they had formerly surmised it might be," and also that it was not, as they before supposed, a land plant, but that it grew in soft mud, most likely of still and shallow water, as they had found its remains associated with an undescribed species of Unio.

On Sigillaria.

None of the vegetable forms constituting the *flora* of the carboniferous epoch have excited more attention, as it regards their

general character, than those which are includod in the genus *sigillaria*.

They are extremely abundant in the great coal formations of the British islands, and are found in a similar and probably contemporaneous deposits on the continent and in North America.

In some instances they appear to have attained a considerable size. M. Adolphe Brongniart mentions a specimen discovered in one of the coal-mines of Kunzwerk, near Essen, in Westphalia, measuring full forty feet in length. I have seen some full that height, while others do not appear to have exceeded ten feet in an advanced stage of their growth.

The genus *sigillaria* may bo readily distinguished by the stems of its various species being externally marked with a number of longitudinal furrows, and by each of the raised spaces or ribs between the furrows having a single row of scars, in some cases nearly in contact, and in others considerably apart.

Various opinions have been entertained respecting the position of *sigillaria* in the vegetable kingdom. Schlotheim supposed it to be allied to the palms; Von Martius to the cactuses and the euphorbias; Brongniart to the tree ferns; while Lindley and Hutton, as stated in the "Fossil Flora," appear inclined to agree with Von Martius, but do not give any decided opinion on the matter. A few years have now elapsed since these opinions were advanced. The discovery, however, of a silicified specimen of this plant at Autun, exhibiting its constituent tissues in a nearly complete state, induced Brongniart, the only author who has since written on the subject, entirely to change his opinion.* At the present time we may safely assume that little has been published

* *Archives du Muséum d'Histoire Naturelle*, p. 448, published in 1839. In this valuable paper, on *sigillaria elegans* the learned author fairly states the reasons for and objections against *stigmaria* being the root of *sigillaria*.

as to the structure and nature of the large specimens of *sigillaria* met with in our coal-fields.

In the year 1839, in company with the Rev. Robert Wallace and Mr. Atkinson, F.G.S., I examined some upright specimens of the stems of *sigillaria reniformis*, which were found resting upon a small seam of coal exposed in cutting the tunnel at Clay Cross, on the North Midland Railway, near Chesterfield. I there distinctly traced a *stigmaria* to the lower part of a *sigillaria*. Not being able certainly to prove the absolute insertion of one plant into the other, it could not be positively affirmed that they were portions of the same plant, but a full conviction was arrived at that Messrs. Lindley and Hutton had been mistaken in supposing that the *stigmaria* was a domed or a cup-shaped plant, and that it had no upright stem. Accordingly, in a paper, read in 1840, on the fossil fishes of the Pendleton coal-field, at p. 178, in the first vol. of the Transactions of the Manchester Geological Society, I stated that the *stigmaria* grew in water, on rich mud, in a bay, like the mangrove of the tropics, at the mouth of the Niger, in the Brass country. For several years after I examined a great number of upright *sigillaria* for the express purpose of acquiring a correct knowledge of their roots.

Many practical colliers having seen upright stems of *sigillaria*, with their roots resting on small seams of coal only 8 to 12 inches in thickness, the floors of which were full of root-like *stigmaria*, very naturally concluded that the latter were the roots of the former. M. Adolphe Brongniart announced that perhaps *stigmaria* was the root of the *sigillaria*, from the great similarity in their internal structure. Professor Wm. King, of Galway, and other geologists have also made similar statements, but their opinion received little consideration, owing to their not being able to bring any facts in support of it.

The first specimens of fossil trees that distinctly proved that

stigmaria was only the root of *sigillaria* were three discovered in Mr. Littler's stone quarry at Scotch Row, St. Helen's, in the early part of 1843. I first saw them on the 9th of August in that year. At the meeting of the British Association, at Cork, I announced to the geological section there the fact of *stigmaria* being the root of *sigillaria*, but no one heeded or believed it, except Sir Charles Lyell, who was at once struck with the importance of the discovery. The late respected Dean of Westminster also immediately threw away his own ideas as to the nature of the plant described in the Bridgewater Treatise, on hearing the above observations on the St. Helen's specimens. On the 28th of October, 1848, I read a description of the trees before the Manchester Geological Society, and Mr. J. F. Bateman, F.G.S., was about the only person who supported the views then put forward. His opinion on the matter was certainly of greater value than those of the gentlemen who held a contrary opinion, as none of them had then seen the specimens just alluded to, but had gathered their information from books describing different specimens. That paper was published in the Philosophical Magazine for March, 1844.

For some time after its publication, owing to the quarry, where the specimens were, not being much worked, they remained unnoticed, until Professor Harkness, F.R.S., and myself uncovered and exposed the large specimen. An account of this specimen appeared in the Philosophical Magazine for October, 1845. Certainly since that time no more conclusive evidence has appeared to prove that *stigmaria* was the root of *sigillaria*. The singular regularity of the roots and their bifurcations—that *sigillaria* were found in situ, midway between seams of coals—were points clearly and decisively proved beyond question by the St. Helen's trees.

In the proceedings of the Geological Society for 1846 is an account by me of the *sigillaria* found at Dukinfield by Messrs. Swire & Lees, and liberally presented by those gentlemen to the Museum

of the Manchester Geological Society. That communication was read on the 22nd of April, in the year just named. The specimen, thanks to Messrs. Swire and Co., was got out of the floor of the mine at great trouble and expense, and placed in the Museum of our Society, where the public can see it. This root is without doubt the most valuable and interesting fossil vegetable that is to be met with in any Museum in the world. The tree did not afford real information beyond what I had obtained from the St. Helen's trees, but it confirmed my opinions in every particular, especially in that of the *main* roots of large specimens possessing none of the characters of *stigmaria*.

In a paper read before the Literary and Philosophical Society of Manchester on the 6th July, 1847, and printed in the Philosophical Magazine of that year, I described a goodly number of *sigillaria* discovered by me in the Pemberton Hill cutting, on the Bury and Liverpool Railway.* It is there distinctly stated that *all the upright trees* (*sigillaria reniformis*) *had roots of stigmaria with their rootlets traversing the silty clay in all directions.*

In a communication to the Geological Society of London, read on the 2nd May, 1849, and printed at page 17, vol. 6, of the Quarterly Journal of the Society, I described the occurrence of spores in the inside of casts of *stigmaria*, and noticed the remarkable crucial sutures found under the base of the stems of *sigillaria*.

In a paper printed in the Quarterly Journal of the Geological Society for 1858 information is given as to the origin of the medulary rays and the nature of the vascular bundles in the pith of *stigmaria*, as well as the structure of the rootlets of the same plant.

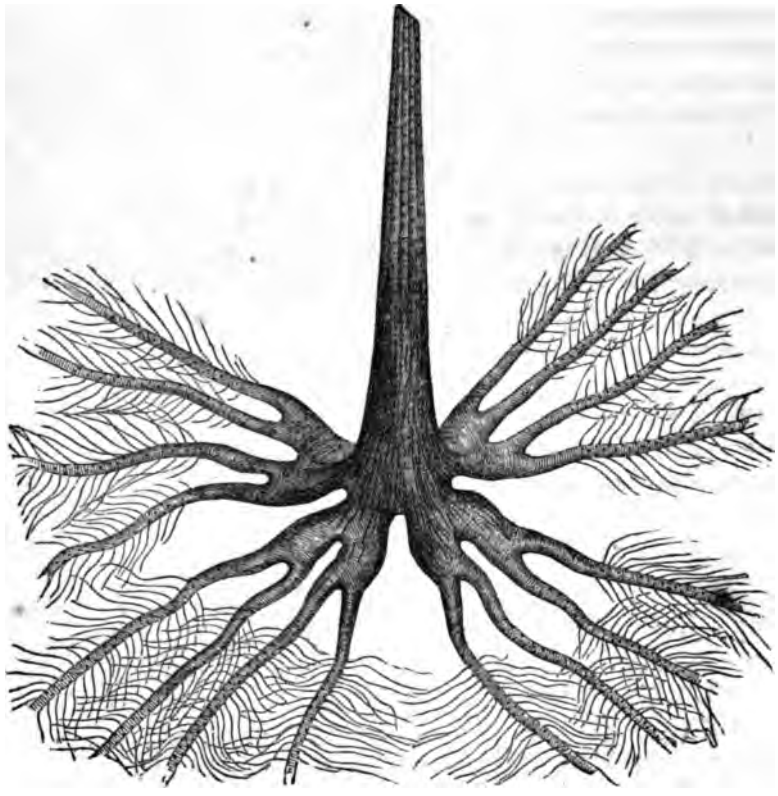
* My friend Dr. J. D. Hooker, F.R.S., visited these specimens with me. I owe much to him for assisting me to make the scientific public believe the facts that I had seen and published. Without his kind aid it would have been difficult to do even that.

The dates of these discoveries and of the papers read and published, are given above, to shew the order in which these discoveries were made, and to point out the gradual progress made in our knowledge respecting this interesting fossil plant.

It seems right to put on record a distinct and connected statement of the steps which led to the discovery of the relation that *stigmaria* bears to *sigillaria*, as well as to give a circumstantial account of the specimens by means of which that discovery was effected, since the value of these specimens, for the purpose for which they were used, is still liable to be under-rated, and, consequently, the completeness of the discovery, to which they so effectually contributed, is sometimes called in question. For, in a work published in 1854, in Edinburgh, on Acadian Geology, by John William Dawson, F.G.S., and which has only lately come under my notice, that gentleman at page 301 of his work, in alluding to Mr. Brown's discoveries on *sigillaria*, states—"Mr. Binney can claim priority in date of publication, but his specimens were much less perfect in details of structure, and therefore less satisfactory than those described by Mr. Brown." Though I have not seen these specimens, yet, from what Mr. Brown says of them, and from Sir Charles Lyell's engraving* it appears, not that *stigmaria* is the root of *sigillaria*, but the root of *lepedodendron;* and it seems that in Mr. Brown's paper on the fossil, printed at page 47 of the Quarterly Journal of the Geological Society for 1847, he describes it as a *lepidodendron*. From the drawing of the specimen, it is almost impossible to make anything out in regard to the genus it belongs to, except that its stem and roots are covered with numerous dots. The only thing it proves is that *stigmaria* is a root, which, at that time, was pretty well known in England, however new it might be considered in America. Aged *sigillariæ*, when decorticated, present on the surface of the lower parts of their stems and main roots a gnarled

* See engraving, p. 315 of Lyell's Manual of Geology—edition 1851.

and ruggedly striated appearance, like an old oak, a peculiarity noticed by my friend, the late Mr. Bowman, in his description of the Dixon Fold trees. In the Dukinfield specimen, with its four main roots bifurcating into 8 secondary and then into 16 tertiary roots, no trace of the arcolæ of *stigmaria* can be seen in any of the main, the secondary, or the beginning of the tertiary ones; they are only seen when the latter assume the thickness of ordinary *stigmaria* at some six feet from the base of the stem.



LARGE SIGILLARIA WITH ITS ROOTS—RESTORED.

My specimens, here mentioned, prove beyond doubt that *stigmaria* is the root of *sigillaria*. It will probably be found that this character of root was common to several other genera of aquatic plants besides *sigillaria*, but this point yet requires to be carefully examined and proved.

In the annexed woodcut* I give a representation of a restored large *sigillaria*, with its full complement of 16 tertiary roots and its cylindrical stem, but I have not ventured to crown it with a magnificent frond of fern leaves as my friend Mr. B. Waterhouse Hawkins, F.G.S., has done in a beautiful small drawing which he has presented to me. Nearly every part can be proved by the Dukinfield specimen previously alluded to.

Up to this time little has been discovered as to the true structure of the wood of large *sigillaria*, and nothing whatever is known as to the foliage of the plant. It is true that M. Adolphe Brongniart, as before alluded to, has figured a small specimen of what he terms *sigillaria*, shewing most beautiful structure, but this fossil would not be ranked with our large *sigillaria* by its external characters. Professor William King, of Galway, many years since, stated that the common fern, *pecopteris nervosa*, would prove to be the foliage of *sigillaria*, but hitherto little evidence has been offered either in support of or against this opinion.

In this communication no attempt has been made to enter into the question of the internal structure of *stigmaria* and *sigillaria*. That of the root is now pretty well known, having been carefully investigated by M. Corda, Mr. Prestwich, F.R.S., and Dr. J. D. Hooker, F.R.S., but the structure of the stem still remains to be worked out. All that has been done is due to M. Adolphe Brongniart, and was made out from the small specimen previously

* I am indebted to my friend, S. W. Williamson, Esq., of Cheetham Hill, for photographing the drawing from which the engraving has been made.

alluded to. At present it may be confidently stated that the central pith of *stigmaria, sigillaria, anabathra,* and of many *lepidodendra,** instead of being composed of cellular tissue, as has been hitherto supposed, really consisted of scalariform vessels of very large size, indeed so large as to raise doubts in the minds of the eminent botanists to whom they were first shewn as to whether they really were vessels. These specimens will soon be figured and published to the world by me.

In conclusion I may affirm that the more I investigate the *fauna* and *flora* of our British coal-fields the more I am convinced of their marine character. This view of the case is becoming more and more common every day.

The thanks of the Society were voted to Mr. Binney for his paper on the motion of Mr. Atkinson, seconded by Mr. W. Blackburne.

A discussion ensued as to the form in which *sigillaria* and *stigmaria* grew.

Mr. Binney said that the *sigillaria* began to dip down at first towards the root, and when it got to the part exhibiting *stigmaria* it ran horizontally. His first idea of *stigmaria* being the root of *sigillaria* was conceived when he was 15 years of age, and he got it from an old collier. He was determined from that time to work it out, but, after he had discovered the fact, and had collected overwhelming evidence on the point, it took six or eight years to make people believe it.

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* The specimens of small *sigillaria* resemble some of the *lepidodendra* so much that it is often hard to determine one genus from the other, and my specimens, shewing pith, are of the small *sigillaria,* and not the large furrowed kind.

ORDINARY MEETING, TUESDAY, JUNE 25TH, 1861.

E. W. BINNEY, ESQ., F.R.S., F.G.S., Vice-President in the Chair.

The Chairman said he was sorry there was no paper to be read. He expected that a gentleman would have brought an improved steam gauge for exhibition, but he had not arrived. He would be glad to hear any geological information from members present.

Mr. Atkinson inquired if Mr. Taylor had heard anything more about the caves at Castleton.

Mr. Taylor said he had not been in that neighbourhood since he mentioned them before. The caves were in the limestone; and the whole neighbourhood seemed to be full of them. About a fortnight before he visited them, there were bones discovered; and he searched for more but could not find any. The bones which had been found were generally covered with stalagmite.

The Chairman said the examination of caves required the greatest care. Foxes and other animals took refuge in them, and the bones of recent animals when covered with stalagmite would, unless great care were taken to prevent it, be mingled with those of animals of far more remote antiquity, thus leading to the erroneous notion that the creatures themselves whose remains were carelessly intermingled in digging up the floor had been contemporaneous. In searching for remains therefore in caverns, the geologist should go step by step, and keep by themselves the bones and other remains which might be found embedded in the successive thin strata composing the floor of the cave. If possible,

too, a portion of the floor should be left standing so as to exhibit a section of the whole, which would afford the means of explaining from what part of the mass any set of fossil remains had been derived. The fact of bones in caves being covered with an incrustation of carbonate of lime, called stalagmite, is in itself no proof of their great antiquity. In many cases, from droppings from the roof in a cavern, the formation of stalagmite is very rapid, its deposition soon covering over, to a considerable depth, any bones that may happen to be scattered on the floor. The covering process may have occupied the space of a few years only; anyone who has seen the Dripping Well at Knaresborough, or the action of calcareous springs in other places, will know how rapidly it is sometimes accomplished.

Mr. Taylor said there was a note in the *Geologist* of last month respecting a paper which had been read before the Academy of Sciences in Paris, about determining the relative ages of fossil bones by the quantity of animal matter they contained. He would like to know the Chairman's opinion on the subject.

The Chairman said the quantity of animal matter left in fossil bones and shells would, in his opinion, depend upon a great variety of circumstances altogether independent of mere length of time. It did not consequently appear that the amount of that matter found in them would afford a safe guide to the judging of the comparative antiquity of fossils. In regard to bones found in caves, the only safe criterion, as to their relative ages, was the position they occupied in the deposit on the floor. In the same cave, in Derbyshire, Yorkshire, and other places, the bones of foxes and other creatures, now existing, and those of the Cave Bear *(Ursus spelæus,)* and other extinct animals, may be found embedded in breccia and in stalagmite, as hard as limestone, forming the floor of their den. Hence it behoves those gentlemen who may undertake the examination of cave deposits—just now a

rather popular and a very interesting pursuit—to proceed systematically, and with great caution, in the business, otherwise, by the co-mingling of materials of very different and distant eras, their labours may be rendered entirely useless in a scientific point of view. In order to determine that the bones belonged to animals which existed at the same time it is necessary to determine that they were found on the same level, that is, in precisely the same stratum of the deposit. He went on to state that there are some remarkable caves at Settle, in Yorkshire, which he should like the Society to go and see, if permission could be obtained. There had been found a great many remains of man—fine skulls, associated with Roman and Phœnician remains, and some rude stone celts, together with a lot of coins of the Emperors Trajan and Adrian: they were found by digging in the floor. A gentleman named Jackson had been investigating the place quietly for a great many years, and had a splendid collection of cave fossils and antiquities. Another gentleman of the name of Burrow, in the same neighbourhood, had also a splendid collection of limestone fossils. He was not aware that any of the caves in Derbyshire had been investigated. A gentleman named Meadows found the tusk of an elephant, somewhere about Dove Holes, near Chapel-en-le-Frith, and that was the only one he remembered to have been found in this district.

Mr. Taylor asked whether the Society had not been invited to Birmingham?

The Chairman said an invitation had been given to the Society to visit Birmingham on the occasion of the meeting of the North of England Institute of Mining Engineers. They were travelling down to Birmingham for the sake of having a larger meeting, and they were wishful to found a Mining College at Durham. He thought the Manchester Society ought to attend to their own mining district before they went elsewhere; and he had had hopes

that the mining people of this district would have made this Society into something like a Mining Institute, as well as a Geological Society; but he was sorry to say they did not attend the meetings as they might, for the busiest day of the week was selected, and business engagements set aside for the convenience of the country members in the mining localities. He was in hopes that next session the members would be prepared with more papers than during the last. He thought their publication should be every month instead of bi-monthly, because when the proceedings were sent to the different publications, they were considered old, and were therefore ignored, as being out of date.

Mr. Atkinson said the Transactions could without inconvenience be published regularly every month, that is, if there were a supply of papers, or anything brought forward that was worthy of publication.

After some further conversation, in which the chairman expressed his regret that the country members did not attend more frequently, the meeting separated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 7.] [Session 1861-62.

The TWENTY-THIRD ANNUAL MEETING, *held October* 31*st*, 1861.

E. W. Binney, Esq., F.R.S., F.G.S. Vice-President, in the Chair.

The following Report of the Honorary Curators was read:—

CURATORS' REPORT.

The Curators report that since the last meeting the keys to the cases in which the collection is kept, have been delivered to them jointly with the special Curators of the Natural History Society. The collection is therefore again in proper custody, and to this extent the Society is reinstated in its rights.

In conjunction with their colleagues they procured the services of John Morris, Esq., F.G.S., Professor in University College, London, to name the Coal Fossils, which has been completed. The whole collection has been cleaned and put in order, and they trust means will be taken to keep it so. They have further to bring before the Society, the great assistance received from Mr. James Parker in the above work.

The Museum is not so rich in local specimens as it ought to be. As a general collection it is undoubtedly a good one; and with the assistance of the members, it can be made one of the first collec-

tions of carboniferous fossils in the country. Attention is particularly directed to the Peel Delph, and other localities where the Peel building stone is quarried, for the purpose of collecting the fossil plants with which this rock abounds. They are not compressed and flattened as is the case in most sandstone rocks, and as specimens, are not excelled by those of any other coal-field.

The collection is destitute of Lancashire Silurian fossils, and very poor in Permian, Triassic and Pleistocene specimens.

It is to be hoped that the Council for the ensuing year, and the members will lose no time in obtaining the *desiderata* above named, and thus make the collection as complete and instructive as so important and populous a city as Manchester requires.

They annex a list of the donations received during the year, viz :—

Books,—1. The Franzensquelle in Eger-Franzensbad, and the Atmospheric Pressure,—by Dr. Cartellieri.

2. The Kammerbuhl, a Volcano near Franzensbad—by Dr. A. Palliardi, from James Hertz, Esq.

3. The Proceedings of the Geologists' Association, No. 5,—from the Rev. L. H. Mordaque, M.A.

4. The Annual Report of the Board of Regents of the Smithsonian Institute for the year 1859, 1 Vol.,—from James Henry, Esq., Secretary.

5. Geological Survey of Missouri, Vols. 1 and 2.

6. Geological Report—South West Branch Pacific Railroad of Missouri, 1 Vol.

7. Grape Culture in Missouri,—by G. C. Swallow.

8. The Rocks of Kansas,—by G. C. Swallow and F. Hawn.

9. Description of New Fossils from the Coal Measures of Missouri and Kansas.

N.B.—7. 8, and 9 are from the Transactions of the Academy of Sciences, St. Louis, Vol. 1, No. 2.

10. Fourth Report of the Progress of the Geological Survey of Missouri, by G. C. Swallow.

The last six (5 to 10) were presented by G. C. Swallow, Columbia, M. O.

11. First Report of Geological Reconnoissance of the Northern Counties of Arkansas, made 1857-8—Presented by the Senate of Arkansas through the Smithsonian Institute.

12. Memoirs of the Geological Survey of Great Britain, &c., the following parts, viz.:—"The Geology of the Country around Wigan," and "The Geology of the Country around Prescot," Lancashire,—both by Edward Hull, Esq., B.A., F.G.S.—from the Author.

13. Flint Implements discovered in Drift on the Continent, and communicated to the Society of Antiquaries,—by John Evans, Esq., F.A.S., F.G.S.—from the Author.

14. Proceedings of the South Wales Institute of Mining Engineers, 13th February, 1861.

15. Journal of the Geological Society of Dublin, Vol. 3, Part 3.

16. List of the Geological Society, London, to September, 1860.

Fossils, &c.—Specimens of Gold-bearing Quartz from Wales.—Presented by T. A. Readwin, Esq., F.G.S.

Fossil Plants from Tertiary Beds, near Wareham.—Presented by James Dearden, Esq., Poole, Dorsetshire.

Sigillaria Reniformis from Peel Delph.—Presented by John Simpson, Esq., C. E., Winwick.

Horn of *Bos Primigenius* from Gravel, Kedlington, Oxfordshire,—by Rev. J. A. Ormerod, M.A.

Ulodendron and others, from Peel Delph,—by H. M. Ormerod, Esq.

Stem of *Sigillaria* from the Oldham Coal-field,—by Isaiah Booth, Esq.

The following Reports of the Council, and of the Treasurer, were then read:—

Report of the Council.

The Council according to usage, bring their duties to a close by presenting to the members a brief report, concerning the proceedings and the condition of the Society during the year they have been in office.

Since the last Annual Meeting the Society has continued, as for a few years past, to increase in numbers, no less than twenty-

seven new members having been admitted in the course of the twelve months, whilst very few of the old ones have disappeared from the list.

Your Council cannot, however, allow the present occasion to pass over without expressing their regret at the loss sustained by the Society through the death of Wm. Peace, Esq., F.G.S.. one of the Vice-Presidents for the year. Mr. Peace was one of the oldest members of the Society, and, to within a few days of his comparatively sudden death, he continued to take a warm interest in the business of the meetings,—more especially with regard to all questions relating to minerals, and the working of mines; and his papers, published in the Society's Transactions, bear testimony to the ardour and intelligence he brought to bear upon these important subjects.

As will be seen by the Treasurer's report, hereto appended, the financial position of the Society still continues to be highly satisfactory, notwithstanding some extra calls that have, during the year, been made upon the funds. Among these calls may be mentioned the re-printing of the first number of the Transactions of the previous year, without which, complete copies of vol. II. could not be made up; and the payment of a considerable sum, in conjunction with the Council of the Natural History Society, for cleaning and naming fossils in the Geological collection, as referred to more in detail in the Report of the Curators. Some slight expense was also incurred in connection with the preparations for an exhibition of Geological specimens at the Meeting of the British Association in this City last September.

During the past Session the following papers were read before the Society:—

1.—Observations on Down Holland Moss,—by E. W. Binney, Esq.

2.—On 'Jelly-peat,'—a kind of Peat found at Churchtown, near Southport,—by E. W. Binney, Esq.

3.—On the Geological Maps of Lancashire,—by Edward Hull, Esq.

4.—On the cause of the Explosion at Hetton Colliery,—by Jos. Dickinson, Esq.

5.—On a Mineral Spring in Germany which is influenced by the pressure of the Air.

6.—On the Geology of Castleton,—by John Taylor, Esq., Jun.

7.—Notice of the Life of the late Mr. Elias Hall, the Geologist,—by E. W. Binney, Esq.

8.—On the Drift Deposits found about Llandudno,—by E. W. Binney, Esq.

9.—On Sigillaria and its Roots,—by E. W. Binney, Esq.

The communications and discussions on the safety-lamp; on sudden outbursts of fire-damp; on ventilation in mines; and on other subjects of a kindred nature, have, there is reason to believe, done good directly, and they cannot fail to prove of great advantage indirectly by awakening inquiry, and by stimulating practical men to the exercise of habits of vigilant and accurate observation,—a frame of mind, sure to lead, in a pursuit like mining, to valuable results.

Hence it is felt that discussions at the ordinary meetings of the Society, may, if rightly conducted and properly reported, be productive of much good. Yet the reporting of such discussions, so as to sift out and preserve the valuable facts and the matured opinions advanced by different speakers, is a work which requires great care; still it is a work that ought not to be neglected, as it will often amply repay all the labour and attention required to be expended upon it.

No excursions were undertaken in the course of the past year. In some of the previous years there were occasionally pleasant and instructive rambles, by parties of the members, into localities presenting Geological features of an attractive kind; and it seems to be worthy of consideration whether a system of periodical excursions, at moderately distant intervals, should not be arranged and

put in practice, as one of the means for keeping up a lively interest in the Society, and for promoting the objects for which it was instituted.

Another means, not yet adopted, has been suggested as likely to be productive of good in the Society. Allusion is here made to the holding of Evening Meetings at the Museum, for the purpose of conversation, and for hearing short lectures explanatory of different groups of fossils in the collection. Could Geological meetings of this kind be adopted, with the sanction and co-operation of the Council of the Natural History Society, there seems to be every probability of their being highly attractive to many of the members who are hardly ever able on account of business engagements, to attend the ordinary monthly meetings, which, for the convenience of country members—certainly a majority of the Society—are held in the middle of the day, on Tuesdays—the busiest day of the week with members resident in town.

Whilst on the subject of suggestions, your Council may state, that in a discussion at one of the ordinary meetings held some time ago, mention was made of the desirableness of making the Society more of a Mining Institute than a Geological Society, the improvement of mining being one of the objects of the Society. As such a project may appear feasible to many persons, it has been thought right to draw the attention of the members to the subject, and commend it to their consideration.

Your Council have to report that the Library has not received any material augmentation through purchase during the last twelve months. It already contains many very valuable works, but the accommodation for their proper arrangement is quite inadequate. It seems highly desirable that measures should forthwith be taken to procure a greater amount of shelf-room for the books, and that several works now existing in numbers or parts should be bound up in volumes, in a cheap form, and be thus rendered more accessible for reference and perusal.

MANCHESTER GEOLOGICAL SOCIETY.

BALANCE SHEET,—1860-61.

Abstract of Receipts.

1860.		£	s.	d.	£	s.	d.
Sept. 30,	Balance brought down				233	11	11
	Subscriptions, 1858-59, 1	1	0	0			
	„ 1859-60, 4	4	0	0			
	„ 1860-61, 92	92	0	0			
	„ Half-year 1860-61, 2	1	0	0			
					98	0	0
	Interest allowed by the Bankers				5	6	1
	Re-payment by Manchester Natural History Society, of share of expenses in naming Collection				8	10	0
					£345	8	0

Abstract of Payments.

1860.		£.	s.	d.	£	s.	d.
	Library				9	10	11
	Reports of Meetings, Reporter, Printing, &c.				46	10	0
	Printing and Stationery				2	7	6
	Advertising				0	10	0
	Postages and delivery of Circulars...				18	15	6
	Collector's Commission				4	18	0
	Arranging and Naming Coal Plants, &c.				20	0	0
	Box for Keys of Cases.....				1	2	6
					£98	14	5
1861.							
Sept. 30,	Balance in the Bank	233	12	7			
	„ Treasurer's hands	13	1	0			
					246	13	7
					£345	8	0

E.E. HENRY M. ORMEROD, Treasurer.

Examined and found correct,

Manchester, 14th October, 1861,

JAMES HERTZ, Auditor.

It was moved by Alderman Harvey, seconded by James Diggle, Esq., and resolved :—

"That the Reports and Balance Sheet now read be entered on the minutes, and printed for circulation."

It was moved by Gisborne Babington, Esq., seconded by George Moseley, Esq., and resolved :—

"That the following Gentlemen be elected office bearers for the ensuing year."

President :

JOSEPH DICKINSON, Esq., F.G.S.

Vice-Presidents :

E. W. BINNEY, Esq., F.R.S., F.G.S.
SIR J. P. KAY-SHUTTLEWORTH, BART., F.G.S.
HON. ALGERNON F. EGERTON, M.P.
THOMAS KNOWLES, Esq., (Clively Bank.)

Treasurer :

H. M. ORMEROD, Esq.

Auditors :

R. PHILIPS GREG, Esq. F.G.S. | JAMES HERTZ, Esq.

Honorary Secretaries :

ANDREW KNOWLES, Esq. | JOHN ATKINSON, Esq. F.G.S.

Honorary Curators :

E. W. BINNEY, Esq.; F.R.S., F.G.S. | H. M. ORMEROD, Esq.

Council :

Wm. Roby Barr, Esq.	Ralph Fletcher, Esq.
Wm. Blackburne, Esq.	John Edwd. Forbes, Esq., F.G.S.
Isaiah Booth, Esq.	Peter Higson, Esq., F.G.S.
Geo. Charlton, Esq.	Rev. Geo. Perkins, M.A.
R. D. Darbishire Esq., B.A., F.G.S.	T. A. Readwin, Esq., F.G.S.
Thos. Farrimond, Esq.	John Taylor, Esq., Junr.

And E. W. Binney, Esq., and Alderman Harvey, Representatives of the Society at the Council Meetings of the Natural History Society.

The routine business having been gone through—

Mr. Edward Lacey exhibited two specimens of lead ore (galena) from a vein which cuts, in nearly a vertical direction, through a seam of coal at Axe Edge, Derbyshire. The coal is 60 yards above the limestone, and, where in contact with the lead, it is not charred or altered in any way; clearly showing that the lead was not introduced in a heated state. The vein of galena is about three inches in thickness, and is contained in a fracture of the strata, or fault, which passes through the rocks above and below the seam of coal. It has been followed about 15 yards above the coal, without presenting any indication of swelling out to a workable thickness; but at present it has not been examined below the level of the coal, on account of the accumulation of water in that direction.

Mr. Binney stated that he had described a similar vein found in Mr. Gisborne's colliery, at Horwich, near Whaley Bridge. The strata there and near Axe Edge were in the same Geological position, namely, the Rochdale series of coals. The bed of coal where the lead was found might be only 60 yards in horizontal distance from the limestone, but in vertical distance it would be near 2000 feet. The Whaley Bridge vein is fully described in his paper printed in the Memoirs of the Literary and Philosophical Society of Manchester.

Some conversation then took place respecting the Davy-lamp, after which the meeting terminated.

MANCHESTER GEOLOGICAL SOCIETY.

NATURAL HISTORY SOCIETY'S ROOMS,

Museum, Peter Street.

LIST OF

HONORARY, LIFE, AND CORRESPONDING MEMBERS.

JANUARY, 1862.

The Names of Honorary Members are printed in Italics.
** Members who have compounded for the Annual Subscriptions.*
† Corresponding Members.

Agassiz, Louis, M.D., Phil. D., Hon. Mem. R. S., Professor of Natural History, Cambridge, Massachusetts.
Atkinson, John, Esq., F.G.S., Thelwall, near Warrington.

Babington, Gisborne, Esq., Newall's Buildings, Manchester.
Balderson, Mr. John, jun., Strangeways, Manchester.
*Bannerman, Alexander, Esq., Chorley.
Barr, Wm. Roby, Esq., Norris Bank, Heaton Norris.
Barton, R. W., Esq., 19, George-street.
Bazley, Thomas, Esq., M.P., Heyesleigh, Stretford.
Binney, Edwd. Wm., Esq., F.R.S., F.G.S., 40, Cross-street.
Blackburne, J. G., Esq., F.G.S., Oldham.
Blackburne, William, Esq., Oldham.
Booth, Isaiah, Esq., Chamber Colliery, Hollinwood.
Birkenhead, E. H., Esq., Mechanics' Institution, Wigan.
Bradbury, John, Esq., Bradbury Green Colliery, Biddulph.

Bradbury, Mr. Chas., Dunkenhalgh Park Colliery, Accrington.

Bramall, Henry, Esq., Chat Moss, Oldham.

Brogniart, Adolphe, Member of the Institute, Professor of Botany in the Museum of Natural History, Jardin des Plantes, Paris.

Brooks, Saml., Esq., Bank, King-street.

Brown, John, Esq., Harborough House, Barnsley.

Bryham, Wm., Esq., Rose Bridge Colliery, Wigan.

Buckley, Edmund, Esq,. 5, Ducie-street, London Road.

Charlton, Francis, Esq.. Rothwells, Little Hulton, Bolton.

Charlton, Francis Price, Esq., Rothwells, Little Hulton, Bolton.

Charlton, Geo., Esq., Dunkirk Colliery, Dukinfield.

Clark, F. C., Esq., Garswood, near Warrington.

Clayton, D. S., Esq., Norbury Colliery, Stockport.

Clough, Saml., Esq., Pewfall Colliery, St. Helens, Lancashire.

Cooke, Rev. S. H,, Great Budworth, Northwich.

Cooper, Thomas, Esq., Congleton.

*Coulthart, J. Ross, Esq , F.R.S. Lit., Croft House, Ashton-under-Lyne.

Cross, John, Esq., Gidlow and Swinley Colliery, Wigan.

Cross, Mr. John, Mining Engineer, Bury.

Crowther, Samuel, Esq., 77, Bradford Place, Manchester Road, Bolton-le-Moors.

Cunliffe, Ellis, Esq., 18, Princess-street.

Darbishire, R. D., Esq,, B.A., F.G.S., 21, Brown-street.

Darlington, James, Esq., Charnock Richard, Chorley.

Dickinson, Joseph, Esq., F.G.S., Inspector of Mines, Vine Grove, Pendleton.

Diggle, James, Esq., Westleigh Colliery, Westleigh.

Dixon, Rev. J. J., Ivy Cottage, Wigan.

Dorning, Elias, Esq., 41, John Dalton-street.

Eaton, Henry, Esq., Mount Zion, Radcliffe, near Manchester.

*Egerton, Sir Philip D. G., Bart., M.P., F.R.S., F.G.S., Oulton Park, Tarporley.

Egerton, the Hon. Algernon F., M.P , Worsley Hall, nr. Manchester.

*Ellesmere, the Earl of, Worsley Hall, near Manchester.

Embleton, S. W., Esq., Middleton Colliery, Leeds.

Enniskillen, Earl of, D.C.L., F.R.S., F.G,.S, Florence Court, Fermanagh.

Eskrigge, R. A., Esq., 24, The Albany, Old Hall-street, Liverpool.

Evans, John, Esq., Edge Lane, Royton, Oldham.

Fairbairn, Wm., Esq., C.E., L.L.D., F.R.S., Canal-street, Ancoats.

Farrimond, Thomas, Esq., York Chambers, King-street.

Ferris, Octavius Allen, Esq., Victoria Park, Manchester.

Fishwick, H., Esq., Carr Hill, Rochdale.

Fletcher, John, Esq., Clifton House, Clifton, near Manchester.

Fletcher, Ralph, Esq., M.A., Atherton.

Fletcher, Samuel, Esq., Parker-street.

Forbes, John Edward, Esq., F.G.S., 8, Faulkner-street, Manchester.

Forster, George Baker, Esq., M.A., Cowpen Lodge, Blyth, near Morpeth.

Fort, Richard, Esq., Read Hall, Whalley, Burnley.

Gerard, Sir Robert Talbot, Bart., Garswood, near Warrington.

Gilroy, Geo., Esq., Ince Hall Colliery, Wigan.

Goodwin, Mr. Joseph, Mining Engineer, Hyde.

Graham, Rev. Philip, Turncroft, Over Darwen.

Greenhalgh, David, Esq., Stubbins, near Ramsbottom.

Greg, R. H., Esq., F.G.S., Chancery Lane, Booth-street,

Greg, R. P., Esq., F.G.S., Chancery Lane, Booth-street.

Hadfield, Geo., Esq., M.P., 24, Fountain-street.

Hadwen, John, Esq., Poynton, near Stockport.

Hardcastle, James, Esq., Firwood, Bolton.

Harter, William, Esq., Hope Hall, Pendleton.

Harvey, Wm., Esq., Acton Square, Salford.

Heelis, John, Esq., 18, Cooper-street.

Hertz, James, Esq., 10, Bond-street.

Hewlett, Alfred, jun., Esq., Haigh Colliery, Wigan.

Heywood, Sir Benjamin, Bart., F.R.S., Claremont, Pendleton.

*Heywood, James, Esq., F.R.S., F.G.S., 26, Kensington Palace Gardens, London (W.)

Heywood, Mr. Geo., Land and Mineral Surveyor, Oldham.

*Higson, Peter, Esq., F.G.S., Inspector of Mines, 94, Cross-street.

Hill, Wm. T., Esq., Wood Hall, Reddish, near Stockport.

Hilton, Thos., Esq., Mine Surveyor, Wigan.

Hodgson, James, Esq., Consulting Engineer, Liverpool.

Horner, Leonard, Esq, F.R.S., F.R.S.E., 17, Queen's Road West, Regent's Park, London (N.W.)

Jackson, Henry, Esq., Astley and Bedford Collieries, Leigh, Manchester.

Johnson, Richard, Esq., Oakbank, Fallowfield.

*Joule, J. P., Esq., LL.D., F.R.S,, Oak Field House, Moss Side.

Kellett, Mr. William, Surveyor, Wigan.

Knowles, Andrew, Esq., High Bank, Pendlebury.

Knowles, John, Esq., Temple Lodge, near Pendlebury.

Knowles, Kaye, Esq., Pendlebury, Manchester.

Knowles, Thos., Esq., Clively Bank, near Pendlebury.

Knowles, Thos., Esq., Ince Old Hall, Wigan.

Lacey, Edward, Esq., Buxton Lime Works, Whaley Bridge, Stockport.

Lancaster, John, Esq., Kirkless Hall and Hindley Collieries, near Wigan.

Langton Wm., Esq., Manchester and Salford Bank, 10, Mosley-st.

Lever, Ellis, Esq., Bankfield Cottage, Manchester.

Litler, Henry Wm., Esq., Oldham.

Livesey, Thos., Esq., Chamber Hall, Hollinwood, near Manchester.

Lyell, Sir Chas., M.A., D.C.L., F.R.S., F.G S., F.L.S., 53, Harley-street, London (W.)

Lynde, Jas. Gascoyne, Esq., F.G.S., Civil Engineer, Manchester.

Manchester, the Right Rev. Lord Bishop of, F.R.S., F.G.S., the Registry, St. James's Square.

Marshall, John S., Esq., 4, King-street, Wigan.

Mordaque, Rev. L. H., M.A., Haslingden Parsonage, Haslingden.

Morton, Charles, Esq., Inspector of Mines, St. John's, Wakefield.

Moseley, George, Esq., St. Peter's Square, Manchester.

*Mosley, Sir Oswald, Bart., F.G.S., F.L.S., Rolleston Hall, Burton-on-Trent.

Moubert, Adolphus, Esq., Garswood, near Warrington.

Murchison, Sir R. I. G. C. St. S., M.A., D.C.L., F.R.S., F.R.G.S., F.G.S., F.L.S., Museum of Practical Geology, Jermyn-street (S.W.) and 16, Belgrave Square, London (S.W.)

Ogden, Mr. Heth, St. Mary's, Manchester.

Ormerod, H. M., Esq., Clarence Chambers, Clarence-street.

Parker, Mr. James, Museum, Peter-street.

Peace, George, Esq., Lord's-Field Colliery, Ashton-under-Lyne.

Peace, Maskell Wm., Esq , Wigan.

Perkins, Rev. George, M.A., Grammar School, Manchester.

Philips, Mark, Esq., Snitterfield, Stratford on-Avon.

Phillips, J., M.A., LL.D., F.R.S., and F.G.S., Museum House, Oxford.

Pickup, Peter, Esq., Towneley Colliery, Burnley.

Readwin, Thos. Allison, Esq., F.G.S., Stretford.

Ridyard, Mr. John, Walkden, Worsley.

*Ross, William, Esq., South Bank, Pendleton.

Satterfield, Joshua, Esq., Alderley Edge.

Sedgwick, Rev. A., M.A., LL.D., F.R.S., Fellow of Trinity College, and Woodwardian Professor of Geology in the University of Cambridge, Trinity College, Cambridge.

Seddon, Mr. Peter, Dunkirk Colliery, Dukinfield.

Seddon, Mr. William, Dunkirk Colliery, Dukinfield.

Shirley, Samuel, Esq., Ivy Place, Harpurhey.

Shuttleworth, Sir J. P. Kay, Bart., F.G.S., Gawthorpe Hall, Burnley.

Smith, G. S. Fereday, Esq., M.A., F.G.S., Bridgewater Offices, Manchester.

Sopwith, Thos., Esq., M.A., F.R.S., F.G.S., 43, Cleveland Square, Hyde Park, London (W.)

Statter, Thomas, Esq., Town Hall Buildings, Bury, Lancashire.

Stott, James, Esq., Kearsley Mount, Stone Clough, near Manchester.

Taylor, John, jun., Esq., Levenshulme.

Taylor, John, jun., Esq., 12, Great Howard-street, Liverpool.

*Trafford, Sir Humphrey de, Bart., Trafford Park.

Turner, Thos., Esq., F.R.C.S., F.L.S., 67, Mosley-street.

*Walker. Jos. Reed, Esq., Calderstones, Allerton, Liverpool.

Wheatley, Mr. Thomas, Shudehill, Manchester.

Whewell, Rev. W., D.D., F.R.S., F.R.G.S., F.G.S., F.S.A., Trinity College, Cambridge.

†Whitaker, Mr. Joseph, 98, St. James's-street, Burnley.

Whitehead, Thomas Lees, Esq., Rochdale.

†Wild, Mr. George, Fulledge Colliery, Burnley.

Wild, James, Esq., Dean House, Buersill, Rochdale.

Wild, Mr. John, Glodwick Colliery, Oldham.

Wild, Samuel, Esq., Dean House, Buersill, Rochdale.
Wilding, William, Esq., Bolton.
Wilkinson, T. T., Esq., F.R.A.S., Burnley.
Wilson, Thomas Banks, Esq., Crimble House, Leeds.
Woods, Henry, Esq., M.P., The Larches, Wigan.
Worthington, Robert. Esq., F.R.A.S., South King-street.
Wynne, Thos., Esq.,F.G.S., Inspector of Mines, Stone, Staffordshire.
Yates, James, Esq., M.A., F.R.S., F L.S., and F.G.S., Lauderdale House, Highgate, London (N.)

HONORARY MEMBERS, EX-OFFICIO.

Captain Thos. Brown, M.P.S., &c.. Curator of the Manchester Natural History Society.
Alex. Campbell, Esq., Curator of the Botanical Society.
J. Plant, Esq., Salford Borough Royal Museum and Library.

COLLECTOR OF SUBSCRIPTIONS.

Richard Aspden, Esq., 92, Mosley-street.

CORRIGENDA—p. 136, for Balderson, read Bolderson.
p. 136, omit Barton, R. W., Esq., &c.
p. 136, last line, for Bradbury Green, read Bradley Green.
p. 139, for Heelis, John, 18, Cooper Street, read Heelis, John, 37, Cross Street.
p. 139, for Joule, J. P., Esq., L.L.D., &c., Oak Field House, Moss Side, read Joule, J. P. Esq., L.L.D., &c., Thorncliffe, Old Trafford.
p. 140, for Moseley, George, Esq., &c., read Mosley, George, Esq., &c.
p. 142, line 6, for South King Street, read 96, King Street.

ADDENDA—The following names have been omitted in the List of Members:—
Brooks, Thomas, Esq., Sunnyside, Rawtenstall.
Buckley, Wm., Esq., Limehurst Colliery, Ashton-under-Lyne.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 8.] [Session 1861-62.

ORDINARY MEETING, *Tuesday, November 26th*, 1861.

JOSEPH DICKINSON, ESQ., F.G.S., President, in the Chair.

The President said,—In taking the chair amongst you on this occasion, being the first ordinary meeting this session, allow me to thank you for the honor which you have done me in electing me President of the Society. It is a post which, in some respects, might possibly have been better filled by some more conspicuous member; but as you have been so kind as to entrust it to me, I shall endeavour to discharge the duties to the best of my ability. With the support of so many valuable coadjutors whose names appear in the Council, and of others whose names do not appear there, but which are absent solely, as it would seem, from want of places to put them into, as well as by the recent additions of talent which the Society has received, I feel that the duties of President are much easier now than the proper fulfilment of such a position involved a few years ago, when the Society was not in its present numerous and prosperous state.

The objects of our Society, as you are aware, are "Geology and Mining." With the former I may claim some association, as

one, who as a field geologist, has examined nearly all, if not every formation *in situ;* and as having been for about twenty years a member of the Geological Society of London. Whatever shortcomings, however, I may have in this respect, I feel that I need be at no loss so long as I can call in the experience of our senior Vice-President, Mr. Binney, whom, so far as I have had opportunities of judging, stands in the first rank of Geologists, and to whom this Society owes an irredeemable debt of gratitude.

With the latter object, Mining, I am, from my associations, most interested; and it will always be a pleasure to me to be able in any way to aid in any matter likely to advance either the safety, or the science, or the profit of Mining. Since I became a member of the Society, I have, so far as the power in me lay, endeavoured, with others, to give practical effect to this object; and I think it has appeared by the attendance at the meetings that the majority of our members recognize as most useful those papers which present information likely to be of immediate practical use.

For both objects, however, the Society affords an old established and valuable local nucleus around which Geologists and Miners may rally; and by which any matter relating to these objects, whether theoretical or practical may be brought under notice and discussion; and to the promotion of each of which I will give my hearty co-operation.

For all practical purposes the Society constitutes for this district a Mining Institution,—and this, perhaps, in the most useful and permanent form. It is true we have no chemical or metallurgical classes; neither do we afford the means of obtaining a knowledge of surveying, planning, and such like; but that is not a want that is felt here. These *desiderata* are well supplied by the private laboratories and offices, and by Owens College in this immediate neighbourhood. For other matters, especially those con-

nected with Coal Mining, our situation is central; and we are surrounded by some of the most advanced, and it may be also, by some of the most backward specimens of Mining.

Our Library contains most useful books on Geology and Mining; and what others may be wanting can be supplied out of the ample funds of the Society.

The Geological room in the Museum is open to the members, and, to their credit, it is also open to the public free of charge; an advantage for which we are somewhat indebted to the arrangements made between this and the Natural History Society, the working of which arrangements I am happy, as our annual report shows, has been, at last, brought into a satisfactory condition.

I hope that many members who have not previously contributed papers will soon do so, and that previous contributors will continue to confer similar favours upon us, and that by active and united action the Society will gradually become more and more useful for the advancement of "Geology and Mining."

The election of the following new members was announced by the Secretaries:—

Ellis Lever, Esq., Bankfield Cottage, Manchester; Mr. Peter Seddon, Dunkirk Colliery, Dukinfield.

The following Donations were laid upon the table:—

1.—A specimen of *stigmaria*—the root of *sigillaria*—exhibiting the rootlets in a matrix of gannister, from the neighbourhood of Sheffield.—Presented by James Yates, Esq., F.R.S., and L.S., Lauderdale House, Highgate, London.

2.—A specimen of Ironstone from Sierra Leone, Africa.—Presented by Wm. Brooke, Esq., Brook Street, Manchester.

3.—Two Books.—Presented by Edward Hull, Esq., B.A., F.G.S.

Mr. Binney said—There is also a specimen of a fossil fish of the genus *Lepidotus*, which has been sent for exhibition at this meeting by the Rev. L. H. Mordacque, M.A. The head and part of the fins only are shown, but it is a very fine specimen. The head is remarkably well preserved.

Mr. Binney then made the following communication :—In the course of the last session a few of the friends of the late Mr. Elias Hall, thought that something should be done to shew where the Geologist of Castleton was buried. His fellow-townsmen appeared not very anxious to do anything to perpetuate his memory; for when a proposal was made for placing a tablet in the parish church, quite a hubbub was raised by some of the so-called gentle folks, to think that a poor old man should have such an honour done to his memory. As the funds collected would not allow of the payment of ten guineas for the fee for erecting a tablet in the church, a good plain stone has been put up over the grave in the churchyard, with the following inscription :—

"*In Memory of ELIAS HALL, the Geologist, who died on the* 30*th day of December*, 1853, *aged* 89 *years.*"

"*Born of parents in humble life, and having a large family to provide for, yet he devoted himself to the study of Geology for seventy years, with powers of originality and industry rarely surpassed.*"

"*To mark the last resting place of one who had worked so long and so hard for the public, a few of his friends and admirers, living at a distance, have placed this stone.*"

The gravestone is just as good as the tablet, which would have cost ten guineas for permission to put it up in the church, even if this privilege could have been obtained for a poor man, without the magnates of the village raising an outcry.

The Reverend Professor Sedgwick on hearing of the erection of a stone, heartily approved of it, and expressed a wish to join in the subscription, if it had not been closed. He said the veteran Geologist was well worthy of a tablet to his memory in his own parish church.

A vote of thanks was given to Mr. Binney for his exertions in this business, on the motion of Mr. G. Charlton, seconded by Mr. A. Knowles.

Mr. John Taylor, Jun., then read the following paper

On Pleistocene Deposits on the Stockport and Woodley Railway.

During the cutting of this railway I have paid several visits in order to work out the position of the drift beds. In the present state of this department of Geology, every fact, duly authenticated, is valuable, and, as I have studied the beds in question with great care, this is my only excuse for bringing the subject before you.

The extent of the above railway is about two miles and a half; and the cuttings are taken through the tops of the higher grounds; the *débris* being used for filling up the valleys. In the length of the railway several distinct sections of the drift beds have been laid open. As yet, the Stockport end of the line has been carried only to a spot a little below St. Paul's Church, Portwood, on the grounds of Mr. Howard. It is here that the first section is exposed. The lower beds of the new red sandstone, at Stockport, may be seen dipping in a north-westerly direction, and, in turning off the Portwood Road to the section above-named, they are again seen cropping out, and are capped below by gravel and clay. These drift beds cover the underlying rocks along the whole course of the line, and hide the junction of the new red sandstone and the coal-

measures. For, about a mile beyond Woodley may be seen several grit-stone quarries in the upper coal-measures, abounding in *Sigillaria*, *Calamites*, *Lepidodendra*, and their associated fossils. The stone used for building the bridges along the line is obtained from these quarries. These few remarks on the position of the underlying rocks lead us to consider the drift beds which cover them.

In the first cutting the depth of the gullet is about twenty-five feet, and the beds here lie in the following order:—

1st and uppermost;—An irregular layer of gravel and thin layers of sand; the pebbles composing the gravel consisting of rounded fragments of granite, syenite, porphyry, and trap, but more especially of sandstone, apparently of carboniferous age; this bed is about twelve feet in thickness, and just caps the summit of the first mound.

2nd;—A layer of very stiff and dark-coloured clay, charged with fragments of coal and black shale. Boulders of a tolerable size are found in it, obtained from various rocks, but more especially from the *gannister;* and lying in heaps by the side of the railway are rounded boulders of rock, similar to the Permian at Collyhurst, and containing fossils such as *Bakevellia*. One large boulder of black limestone, which I dug out of the clay myself, furnished me with tolerable fine specimens of *Goniatites reticulatus*, *G. Listeri*, and *G. Leylandi*. This clay bed is from eight to ten feet thick, and nearly all the boulders are polished and striated; some of them so polished as to give the appearance, when first dug out, of having been black-leaded.

3rd;—A bed of very fine red and yellow sand, similar to that found near Stockport station. This bed contains in some places

layers of dark carbonaceous matter, which soils the fingers upon touching it. It extends to an unknown depth.

These beds are found lying in the first cutting in the order in which I have named them. The cutting is about two hundred and fifty yards long. At the end may be seen, imbedded in the gravel, a huge boulder of coarse-grained syenite. Since going over the grounds, in company with Messrs. Binney and Barr, when this boulder was lying *in situ*, its upper surface quite smooth, I found that it had been disinterred, and turned over, so that it has now its under side exposed, and shows most evident traces of the scratchings to which it has been subjected by grating on the old sea bottom. In this first cutting we find the lower beds of gravel of a coarser texture than the upper, owing to the water not being able to percolate through the clay, filtering through them, and carrying away with it the finer particles of sand and gravel. These lower beds are quite moist, owing to the above cause.

At the next cutting, some two hundred yards further on—and which is about four hundred yards long—the clay is seen lying undermost, and is of a very great thickness. It is just capped in the beginning of the section by layers of gravel and sand. In some places the sand is quite black, and so hard as to be only broken with a hammer. This blackness has been evidently caused by the decomposition of vegetable matter—old drift-wood, or huge masses of sea-weed which were buried in the sediment of the glacial seas. In these beds there lies another large boulder of fine-grained red granite, not so large as the one first-mentioned, but still of a tolerable size. The underlying clay is very fine, and adhesive, as I, and the gentlemen I have named, found out one moist Saturday afternoon. What seems to me the most singular fact connected with it, is the presence of numerous branches and roots of trees, apparently of coniferous wood. Some of them appear to have been chopped and sawn, and are found lying at a depth of fifteen feet

from the surface. The specimens upon the table are fragments which I obtained during a recent visit.* From this place we take leave of the gravel beds, and clay beds,—into which layers of sand are found, often feathering out and losing themselves, only to appear again in a short distance,—predominate. A little further on brings us to a place where the clay is capped by about six or eight feet of course sand, charged with carbonaceous matter. This series is succeeded in the next cutting by alternating layers of clay and sand; the clay, however, greatly preponderating, and often presenting the appearance of having been *felted* together. It lies in thick layers, and apparently only wants consolidation to convert it into shale. Polished and scratched boulders are still common in it. The depth of the gullet here is about thirty feet. About a quarter of a mile further on, this series alters, and the underlying sand comes up. Here the sand, which is capped by about twenty feet of *till*, is found to contain numerous fragments of marine shells, belonging to the genera *Mactra*, *Tellina*, *Venus*, *Cardium edule*, and *Turritella terebra*. Most of these fragments give evidence of having been exposed to a rolling action among the grains of sand in which they are imbedded. Although these fragments are numerous, entire shells are rather rare; still, there is sufficient evidence that these beds need only careful examination to prove them anything but unfossiliferous.† The sand beds in which they lie are also mottled with carbonaceous matter,—the relics of the ancient algae which composed it. This series continues to the end of the railway cuttings,—sand below, and clay above. At Woodley this clay is dug into for brick making, and for the manufacture of tiles.

Few and simple as are the facts which I have recorded, still, I

* I may just say that the clay in which these branches occur, is capped by a layer of coarse sand, three or four feet thick.

† The shells, which are chiefly found whole, are those belonging to *Turritella terebra*.

cannot help regarding them with a great degree of interest. In studying them more minutely we find in these later deposits that the same phenomena of denudation and deposition which characterized the older strata, are exhibited even in Pleistocene times. The dark-coloured beds of clay, charged with fragments of coal and shale, in which, also, lie boulders of sandstone and limestone, clearly point to their derivation, and tell how the numerous escarpments and ravines,—which, prior to glacial times, must have intersected the neighbourhood of a coal country from the faults and dislocations caused by upheaval of the solid rocks,—have been slowly worn down to their present appearance. The numerous fragments of *gannister*, with their enclosed fossil rootlets of *stigmaria*, as well as the fragments from the Permian, tell of the extensive denudations which some parts of our Lancashire coalfield have suffered. Then the huge boulders of granite, along with the smaller and more rounded fragments of porphyry and trap, tell of the time, when, drifted by icebergs from their ancient deposits, they were strewn along the old sea bottom. And the red sand below—which only requires re-consolidation to convert it again into *new* red sandstone—evidences by what agency, and at what time, the basin in which the lower part of Stockport now stands, was scooped out of the solid rock. We learn from the recently published work of Dr. Maury, that the bottom of the Atlantic is an inclined plane, formed from the accumulating materials dropt by icebergs as they float southerly, until, as they come upon the Gulf-stream, they suddenly melt, and so finally drop all that they have remaining, thus forming a tolerably steep escarpment in a line with the places where the Gulf-stream crosses the Atlantic. Such circumstances, however, do not seem to have prevailed during the time of the northern drift. Then the order of things was reversed, and the thicker deposits were more northerly, and thinned out in the southerly direction. It is probable that, during this later period, the neighbourhood of the above deposits was covered by a shallow sea, in which icebergs became stranded, and thus pounded

and crushed the solid rock into gravel and sand. It is further probable that at this time, what is now the chain of hills commonly known as the "back-bone of England," were low lands covered by a wintry growth of coniferous trees. The whole of these deposits in short, in their varying characters, plainly tell of the littoral conditions under which they were accumulated.

Recent as the above deposits are, geologically speaking, yet the time taken up in their formation must have been immense, in the gradual wearing and denuding of the carboniferous rocks, to form the clays, and in the breaking up of the old igneous deposits to form the gravels. This extent of time, however, may have been equalled by that which has elapsed since they were formed. These high grounds—some one hundred and fifty feet above the river—have since then been slowly upheaved from the bottom of the sea. During this slow uprising, the river on the left hand cut its way through the superficial deposits, and even through some twenty or thirty feet of solid rock besides, as may be seen in several places about Stockport. That the river was considerably broader then than now is plainly indicated by the terraces which it has left all the way down the valley; whilst the shifting of its bed, now on this side, and now on that, has deposited the sand and mud which lie below.

Great as the period of time must have been during which these changes took place, the whole of them have been effected in the lifetime of existing species of shells! The old drift streams, in bringing together and commingling the ingredients of the various rocks, have served the same purposes as those which man attempts when he adds mineral manure to his lands; and, doubtless, had it not been for this finishing stroke of the Creator—had not the Temperate Zones been covered by such a sub-soil of gravel and sands—a scant and meagre vegetation would everywhere have greeted the eye. And thus like the fabled Philosopher's stone,

which turned the baser metals into gold, time can make the most common things venerable, and a patch of gravel or clay, viewed in the light of Geologic science, furnishes to us the history of our Planet just before, or contemporaneously with the epoch when man was called to take possession.

On the motion of Mr. Binney, seconded by Mr. W. R. Barr, the thanks of the meeting were given to Mr. Taylor for his paper.

Mr. Binney said Mr. Taylor had kindly shown him and Mr. Barr the drift sections here referred to, and he thought them very interesting. The occurrence of these shells was new in this district, although they had been found further up, at Tintwistle. The gravels which Mr. Taylor had first described, he took to be merely valley gravels, but these shells were imbedded in the till, and there seemed no doubt that they were pleistocene fossils. He had seen the specimens of trees, but he was always doubtful of specimens of that kind when found near the surface. They might be merely the remains of an old pit.

Mr. Barr remarked that since his visit to the drifts spoken of by Mr. Taylor, he had found the valve of a cockle embedded in the sand, in the gravel beds near his own house, about three miles below these drifts. In the centre of the shell was a piece of coal, and there were other pieces of coal near, which seemed more like cinders than anything else, as if they had been decomposed.

Mr. Binney thought it was very desirable that a further search should be made, for it was just possible that the half of a cockle shell might have come from a nearer source than the one indicated.

Mr. E. Hull said he had paid considerable attention to the river terraces in the neighbourhood of Stockport, and certainly they were the most remarkable of any he had ever come across. They

seemed to rise one above the other to a height he supposed of at least one hundred feet above the level of the river. This was the case near Didsbury on the north bank of the river, and to the west of Stockport. He should like to be informed whether these shells, now found in the boulder clay, were the same as those at present found in the Irish sea.

The President said he thought Mr. Binney's suggestion with regard to the branches of trees was well worth consideration. They all knew that in going over the old ground they sometimes came across places where former generations had been, and of which, but from information, they should otherwise know nothing.

Mr. Taylor observed that the till itself bore no marks of having been disturbed. However, he drew no inference from the existence of these old branches. He merely mentioned the fact.

Mr. Binney—There was nothing in the depth I saw which a tree might not have reached with its roots.

Mr. Hull said that the base of the till generally formed a distinctly marked line. There was a section on the railway, very near to Stockport, where the till could be seen resting upon the sand.

Mr. Binney—What we want with regard to drifts is an immense collection of facts. I thought twenty years ago that I had got enough facts, and might begin to generalize, but I find even now, after twenty years, that this is not the case.

Mr. Joseph Goodwin then read the following paper

On the Ventilation of Mines.

Mr. President and Gentlemen,—Having made a promise at our

last meeting to read a paper on the ventilation of mines, and the safety lamp and its uses, I will, by your kind permission, first take up the subject of the ventilation of mines. I had intended to have disposed of the subjects in two papers, but finding that the time allowed for the discussion of the first paper would be necessarily curtailed by Mr. Taylor's paper taking up a portion of your time, I have determined, if agreeable to the Society, to divide the subjects so as to form three papers. I may add that I have been somewhat influenced in adopting this course by a desire not to trespass at too great length upon your valuable time, and that all that may be advanced by me may be fully and fairly discussed. The subject of my paper is certainly one that is worthy of the fullest consideration, and it would be somewhat difficult to find another of equal importance, not only to the mining world, but the community at large. It is to this and such like Societies that I look forward as being capable of dealing with this, and many other subjects, in such a manner as to be productive of much good. I pray you will excuse me making the remark that this Society is neither so practical in its character nor so wide in its range as I hope it may be ere long.

I shall not trespass upon your time in describing the various methods of producing a current of air, but content myself with observing that the furnace possesses advantages over all other methods of producing a current of air that we are at present acquainted with; and it may safely be added that from its simplicity of application, and its constant power of action, it is likely to maintain its position for a long time to come. Objections have been raised to its use, on the ground of its liability to ignite the return air, if it should happen to be charged with gas, so as to render it explosive. For my own part I do not admit this as a valid objection, and flatter myself that many of the gentlemen present will agree with me in saying that this contingency may always be guarded against by admitting a current of air fresh from the down

cast into the return air course, and this too without materially affecting the quantity of air passing through the workings of a mine. The objections raised against Struvé's Ventilator, and other mechanical means of producing a current of air, by myself, and others of far greater authority, have, unfortunately, proved too well-grounded; as is shown by the recent South Mostyn explosion. A more signal failure it is scarcely possible to conceive, or one that might have been attended with more direful effects. The advocates of this system of producing a current of air partially succeeded in showing that the unfortunate Risca explosion was not to be attributed to the limited powers of Struvé's Ventilator, nor to its defect. But no sooner had they finished their difficult task then a more formidable one presented itself. Whether the system will find supporters willing to undertake the task of explaining away the circumstances under which the Mostyn explosion occurred, and load themselves with the vast responsibility that will attach itself to anyone further recommending the system, remains to be seen. I have never looked upon the mere production of a quantity of air, however great, as of that importance which many attach to it. It is doubtless necessary to have a sufficient quantity of air passing through the workings of a mine to render it both safe and healthy; but the ventilation of a colliery cannot be correctly estimated by the number of cubic feet of air that passes through the main air courses each second or minute. The proper distributing and dividing of the currents of air, so that each portion of the workings shall have an adequate share, must be attended to, or it is vain to talk of the quantity of air passing through a mine.

In order that the distribution of air throughout the mine be properly attended to, it is necessary that not only the fireman and the underlooker, but the manager also, be acquainted with the progress of all the workings under his charge, and that the same be constantly kept before his mind's eye, or he no longer is capable of resting upon his own judgment, even after having heard the

views of those placed under him. When a colliery manager or viewer ceases to examine for himself, and depends upon the judgment of others, without first satisfying himself that the judgment of those he relies upon is superior to his own, he no longer is the manager except by name, and ought to be designated manager by proxy. The principles of ventilation are exceedingly simple in theory, and well may the theorist express astonishment at seeing them so often violated in practice; but it is a very different undertaking to ventilate a colliery upon paper, and to do it in practice. For instance, what is easier in theory than to increase the area of the air courses to such an extent as to render the drag or resistance of the air currents almost nominal. But in practice, I need hardly observe, there is a limit beyond which it is impossible to go. This is not the only point upon which difference exists between practice and theory in the ventilation of collieries, for the same difference pervades almost every branch of ventilation; hence the reason of so many absurd and impracticable schemes being brought before the public by those who know nothing of the difficulties by which they would be beset in reducing to practice that which appears feasible upon theoretical principles.

I do not wish to convey the impression that the difficulties consequent upon ventilating the most fiery seams are insuperable, but, on the other hand, I have the strongest conviction that the subtle enemy, fire-damp, when found in its most dangerous form, may be subdued, and brought within such bounds as to render the mine comparatively safe and healthy for the workman, and perfectly safe for the capitalist. But in order to accomplish this, it requires not only that the managers of collieries should perfectly understand the principles of good ventilation, but that they should also be attentive to their duties, and pay the strictest regard to those principles being carried out in practice. In order that a manager or viewer may do this, it is necessary that his duties should be confined within some reasonable bounds; as colliery managers, like other

individuals, can only perform a certain amount of labour. It is true, system and order will permit an active-minded man to perform much mental labour, as will also a strong and robust frame permit one to perform much physical labour; but upon what principles and by what means individuals can successfully manage or view ten or a dozen collieries, besides spending much of their time in travelling, is a mystery to my mind. To say the least, those who can perform such feats of strength and skill, would be pre-eminently fitted for being resident managers of only one colliery.

In ventilating a colliery especial care should be taken that the drag or resistance of the air-currents should be reduced as much as possible, by having the air courses of as great an area as the nature of the roof or stratum overlying the coal will permit of, and by splitting or dividing the air currents as often as practicable. By splitting or dividing the currents of air passing through a mine, not only is a greater quantity of air put into circulation but the quality of it, so to speak, is improved; each workman also by this system of ventilating, is enabled to breathe moderately pure air, and if an explosion should occur, it would in all probability be confined to that division of the workings where it was ignited,—whilst the effects of the explosion would be much less serious.

I know of no greater barrier to effective ventilation than obstructed air-courses; and certainly there is no branch of ventilation that is so much neglected. We have it given in evidence upon the enquiry into the causes of the most destructive explosion that ever occurred in this country,—that the viewer or manager had avoided travelling through one of the main air-courses of the mine for weeks before the explosion, in consequence of its being almost made up by falls of dirt, &c. I have pointed out this case in order to show what fearful effects may be produced by what is often considered as only of slight importance. This is far from being an isolated case, but it ought not to require more to show the necessity of avoiding obstructed air-courses. I grant that

in some mines, and under some circumstances, it is extremely difficult to maintain air-courses, anything like their original size; but these are only exceptional cases, and are often the result of getting coal upon erroneous principles, or from want of judgment in laying out the workings of a mine. But the exceptional cases, granting that they cannot be guarded against, afford no excuse for the general disregard that is paid to this important branch of ventilation. A greater anomaly can scarcely present itself to the mind of anyone understanding the correct principles of ventilation than to see a powerful furnace or other ventilating agent worked up to its utmost pitch in order to drag just a sufficiency of air through the tortuous cramped air-courses of a mine, to prevent the whole atmosphere of the mine being at the explosive point.

The useful effect of the ventilating agent is often impaired from not allowing it the advantage of being assisted by natural means. In some mines, and under some circumstances, the assistance that may be afforded to the ventilating agent is very considerable. One way in which assistance may be afforded to the ventilating agent (especially in mines lying at high angles of inclination, and giving off much fiery damp) is to ventilate upon the principle of having the upcast as near the highest point of the workings as practicable, and allowing the light carburetted hydrogen to pass off into a main return air-course maintained on the rise of the workings. Every-day experience confirms the fact that the light carburetted hydrogen of our coal mines will occupy the highest position in the workings, and that by virtue of its light specific gravity, it requires little power to pass it off up the incline of the mine, when the angle is 15° and upwards. In proof of this I need only remark that we have no well authenticated case of fire-damp or light carburetted hydrogen gas ever being known to lodge in workings driven down brow, where the angle of the mine exceeds that named, or even approaches it; that is, if the down-brow workings are connected with or open into an air

course above the workings. It is only necessary to take into consideration the weight of 100 cubic inches of atmospheric air, and the same number of inches of light carburetted hydrogen gas, to see the folly of dragging the latter down the incline of the mine and allowing it to ascend to be dragged down a second and perhaps a third time. Where the angle of inclination of the mine is 15° and upwards, very much loss of power is experienced by the ventilating agent, if this system be practised, and it is by no means an uncommon method of ventilating fiery seams. It will perhaps not be considered out of place to state the weight of 100 cubic inches of atmospheric air and the same number of cubic inches of pure light carburetted hydrogen, although it might have been more proper to have reserved it for a future paper. The weight of 100 cubic inches of pure light carburetted hydrogen, upon the authority of Brande, is 16·994 grains; but he very much questioned whether it ever was or could be artificially produced. The weight of the same bulk of atmospheric air is 30·409 grains, with the pressure at 30 inches and the temperature at 60°.

It is too often the case that a mine is designated as a fiery seam when, comparatively speaking, the quantity of light carburetted hydrogen that is generated or given off is only very slight if proper means were adopted for effectively ventilating the mine. I have myself seen mines in which the air has almost been in a quiescent state, and charged with fire-damp to such an extent as to be almost at the explosive point; and such cases have been presented to the public through Her Majesty's Government Inspectors of Mines, on different occasions; but I fear those that are brought before the public do not constitute the whole of the mines that are to be found in that state. But however much I may know of the evils of the system referred to, it would be unbecoming on my part, and exceeding my duty as a member of this society, were I to refer to one single case that has not appeared before the public. Nor is it necessary, as abundant proof

exists of the misery and destitution that have been caused by the want of ventilation in mines that would have been perfectly safe had proper measures been taken to have rendered them so. If all in the position of colliery managers would only pause and well consider the evils consequent upon neglected ventilation, and compare the slight advantage thus gained, (admitting a temporary advantage to be gained) with the great risk they subject themselves and their employers' property to, I feel confident that the evil would not continue to be so wide-spread as at present. And this is only slight compared with the injustice inflicted upon the workman by practically compelling him to injure his health and destroy his constitution by working in a vitiated and poisonous atmosphere. Whatever may appear to be saved in the working expenses of a colliery by ineffectually ventilating it, is false economy; and if accurate information could be obtained, it would be found that in all cases it is more economical to thoroughly ventilate the workings of a colliery than to seek to effect a saving by neglecting this important branch of colliery management. Fearing that under present circumstances I have already trespassed too long upon your time, I will not say more on this occasion, but shall be happy to resume the subject and enter into the details of ventilation at any future time that may be agreeable to the society.

A vote of thanks was accorded to Mr. Goodwin, on the motion of Mr. Atkinson, seconded by Mr. Binney.

Mr. Geo. Charlton said he felt quite confident he spoke the feelings of the colliery managers of Lancashire generally when he said it was very unfair on the part of Mr. Goodwin to put before the public the statement that the cause of accidents in coal mines, was the want of good management. He, Mr. Charlton, denied that there was any want of disposition on the part of proprietors to make their collieries perfectly safe. He was bound to say, so far as the col-

liery proprietors of Lancashire were concerned, that there never was a time when so much ability was displayed in the management of coal mines. With regard to the desirability of having the upcast shaft as much towards the rise of the strata as possible, it was an ascertained fact, that the longer the upcast shaft was, the better was the ventilation. In proof of this he could refer to the Dukinfield deep pits, under his own charge, where the upcast shaft was nearly 700 yards in depth. According to the theory laid down in the paper just read, they ought to have sunk the shaft to the rise of the coal. He was prepared to say that this would have been a very unwise thing for the Company to have done. By adopting their present plan they had secured a very efficient system of ventilation. It was very desirable to have a large amount of atmospheric air, and to produce that current of air, the longer the upcast shaft the better.

Mr. Binney said he was sure there was no gentleman there who would not bear Mr. Goodwin out in saying, that the first thing to be done in the ventilation of a mine was to get a good current of air, and to distribute it well. He thought, also, that everyone must agree with the next part of the paper,—that there could not be too much supervision by managers and officers. A man who had charge of the lives of 500 men, certainly ought to be a well-educated man, and ought to be well paid. They all knew that great progress had been made in Lancashire in the management of mines, and when accidents did occur they arose from remissness, not from wilfulness.

Mr. John Fletcher regretted that there should have been so much disposition to throw blame upon managers. He thought that any gentleman at all familiar with the colliery management of this part of the country, must be ready to admit that the utmost

pains were taken on all occasions to prevent those sad occurrences which not only occasioned loss of life to the miner, but loss of property to the proprietors. But even the cleverest of them could not establish a system which should be at all times unattended with misfortunes; and therefore he thought that a better effect would have arisen from the reading of the paper, if Mr. Goodwin had omitted to insinuate that accidents frequently occurred through the want of proper management. Mr. Goodwin's views with regard to the amount of atmospheric air, were as old as the days of Methuselah. His opinion with regard to the position of the upcast shaft, and with regard to the downcast, were matters for discussion.

The President said he thought perhaps they had better take as a little rub, without making too much of it, the remark of Mr. Goodwin with regard to their Society not being of a more practical nature. This was a want which they had all felt at times, but the difficulty was how to remedy it. Some who had worked at it knew this was not a thing to be done in a day. Without saying anything further on this subject, he might remark that there were some really useful points in the paper just read, points which ought to press themselves on the attention of the managers of mines. For instance—what was the best motive power for ventilating coal mines? Mr. Goodwin, as nearly every other colliery manager did, seemed to anchor himself to the furnace. We, in this country, had always been anchored to it, and had never given any other system of motive power fair consideration. In South Wales, where they were subject to constant emanations of fire-damp, the air pump, and other mechanical means of ventilation, had been actually forced upon the attention of miners. In Belgium, the furnace, though by no means so well practised as in this country, was still practised, but mechanical means were there found best as a motive power. He did not wish to commit himself to any definite

opinion, for at the present time, he, in conjunction with his colleague, Mr. Atkinson, the Inspector of Mines for South Durham, was engaged in a series of experiments to test all the known ventilating machines in this country, and also in Belgium, so as to ascertain, as far as possible, what was the relative value of the various agencies in use in mines. They had already visited the mines in South Wales and Monmouthshire, and they had found that some of these machines were really giving out an extraordinary amount of horse power, whilst others were giving out a much smaller per centage. He hoped in a short time to know what were effective machines, and what not. He did not wish to disparage the old furnace, which for deep pits had certain advantages over mechanical means. But for shallow mines an amount of power had been obtained by ventilating machines which could not be obtained by any furnace, even if they heated the shaft red hot. These were questions all of which required to be very carefully gone into; and he knew of no more useful way in which the Society could be occupied than by going into these matters. He thought it would be wise for them not to commit themselves to any particular motive power at present, but to adopt those which they thought best under particular circumstances. All these subjects, and the position of the upcast shaft, and whether ascensional ventilation was the best, were matters of calculation, regulated by certain known and fixed laws. Each and all of these had merits of their own, which could be duly awarded to them without depreciating other systems.

Mr. Charlton, in support of the Chairman's remarks, mentioned that he had been present at Elsecar, at a trial of Earl Fitzwilliam's ventilating fan, and his own opinion was, that when this fan was completed, it would entirely supersede the furnace.

Mr. Goodwin, in reply, said he was exceedingly sorry that Mr.

Charlton had taken this matter up in the spirit he had done. He (Mr. Goodwin) had never charged the proprietors of mines with a want of a disposition to have proper management. What he did say, and what he again asserted was, that accidents frequently occurred through defective management, and when they had before them the fact that the two last accidents had occurred from that cause, he thought few persons would doubt his statement. When they had subjects of this grave importance to deal with, they should not be touched as if they were bars of iron, white with heat, but should be fairly grappled with.

Mr. Parkinson, 146, Oxford Street, Manchester, exhibited a Safety Lamp in which he had introduced modifications which he considered would add materially to the safety of that valuable instrument. In the first place, to prevent the lamp from being opened by the workman in the pit, he proposed to fasten the lamp by a screw sunk some depth into the lamp, and into the depression at the head of the screw, to melt, by means of a blow-pipe, a piece of solder; thus rendering it impossible for anyone to unscrew the lamp till the solder had been removed by means of a blow-pipe. He said thirty lamps could be fastened in this way in an hour.

The second improvement proposed was an extinguisher hung from the top of the lamp inside; the suspending wire being connected to the extinguisher by a solder so tempered that when the lamp became unduly heated, the solder would melt, and allow the extinguisher to fall upon the wick of the lamp and put it out. The solder could be made to melt at any required temperature, so as to ensure safety by causing the lamp to be extinguished before it became so heated as to ignite any explosive gas that might be present in the pit.

The President said the first of Mr. Parkinson's proposals was not new—in principle, at least. Already the plan of driving a plug of lead into the hole at the top of the screw had sometimes been adopted; but the proposal to employ an extinguisher in the way here indicated, was, as far as he was aware, partially new; and it certainly seemed to be a suggestion deserving of the attention of gentlemen engaged in the management of coal-mines.

A vote of thanks having been given to Mr. Parkinson for the exhibition of his improved lamp, the meeting terminated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 9.] [Session 1861-62.

ORDINARY MEETING, *Tuesday, December 31st*, 1861.

JOSEPH DICKINSON, Esq., F.G.S., President, in the Chair.

The President stated, that Wm. Buckley, Esq., Limehurst Colliery, Ashton-under-Lyne, had that day been elected by the Council an ordinary member of the Society.

The following donations were announced:—

1.—Abstracts of the proceedings of the Geological Society, London, Nos. 70 and 71, from the Council of that Society.

2.—Fossil Shells from the coal-measures, Little Hulton, and a specimen of Trigonocarpon elongatum from Peel, from H. M. Ormerod, Esq.

3.—Several mineral specimens from Devon, presented by G. W. Ormerod, Esq., M.A., F.G.S., Chagford, Exeter.

4.—A specimen of Cannel from South Wales, presented by the President, who stated that the occurrence of Cannel in the South Wales coal-field was very uncommon.

The thanks of the Society were voted to the respective donors.

Mr. Binney exhibited to the meeting a specimen of granite containing petroleum, sent to him by James Yates, Esq. F.R.S., of London. He stated that he had communicated to the Society an account of petroleum from peat bogs, so as to show that such substances were now in the process of formation, but he had never before heard of petroleum having been found in granite. Mr. Yates stated in his letter to Mr. Binney "that he could find no specimens similar to his either in the museums at the Geological Society or in Jermyn-street." Mr. Robert Hunt, F.R.S., was well acquainted with the specimens, and thinks that they are now extremely rare. He has sent Mr. Yates the only record he could find about this substance, stating that about 30 years ago there was discovered in the great copper lode at Carharack, at the depth of 70 or 80 fathoms, a quantity of bitumen, dispersed throughout the substance of the lode and the contiguous growan. Mr. Yates obtained his specimen in 1818, and it is mentioned in Aiken's Mineralogy, 1815, p. 60, so that its discovery is of older date than 30 years ago. Copper and tin ores accompany the bitumen. There is no coal in Cornwall, on which account Mr. Hunt thought this bitumen could not be of vegetable origin, but formed by the chemical carbonates of mineral or gaseous matters. All the accounts state that it was found in mineral veins passing through the granite. Mr. Binney said that all bitumens or petroleums, so far as yet known, were formed from organic substances, and no instance was known of any having been found formed from brute matter, whether mineral or gaseous. Although the lode in which the bitumen or petro-

leum was found did occur in granite, it was not necessarily of great antiquity, as the lode might have been formed at a comparatively modern period, and the bitumen introduced at that time.

Mr. Joseph Goodwin, having then been called upon by the President, read the following paper—

On the Ventilation of Mines.

Mr. Chairman and gentlemen—In resuming the subject of my paper, permit me to observe that it is one which all who are desirous of forwarding the interest of practical mining, must necessarily take a deep interest in, and alike feel the necessity of employing the best means in their power to arrest the evils arising from deficient ventilation. So far, an unanimous feeling appears to exist; but as to the best manner of dealing with the subject, great diversity of opinion is to be found. It may be considered that the manner of dealing with the subject that I have chosen is somewhat peculiar, and that it is not the best course that might have been adopted. However, I beg to assure every gentleman present that after very carefully weighing over the subject in all its bearings, and taking the views of some of the most extensive and highly respectable proprietors of mines in this district, I have been compelled by force of conviction to adopt the course I have chosen, in the earnest hope of rendering some permanent good to the mining world. I have allowed neither interested nor vindictive motives to influence or guide me in anything I have either said or written upon the subject, and sincerely hope that if, on the other hand, any opposition may be raised to my views, the same motive, namely, that of forwarding the interest of practical mining may influence those who choose to differ with me, and whose right to do so I do

not dispute. In dealing with any other subject that happened to be as far from perfect as the colliery management of this country is, it is questionable whether there be one person present that would not inquire into the causes of its imperfections, and at once devote his attention to the removal of them. Why should we make this an exception? We may deal with the subject in an abstract manner from now till doomsday without producing the required effect; but if we trace out the evils and use our powers in endeavouring to remove them we may reasonably hope for improvements that will exercise a beneficial effect upon all connected with mining, whether in a direct or indirect manner. How can a physician successfully treat a disease without first knowing its source? On the same grounds, how can we expect to administer relief and check the feeling that is daily growing stronger, that all is not being done in the mining world that might be, to arrest the tide of disasters that continues to flow with unabated effect? Surely not by being afraid of free inquiry into the causes that produce the evils that we are all alike desirous of removing.

It must be admitted by all who have carefully considered the subject and weighed over the evidence adduced at the respective inquiries, that it is not new principles that are required to prevent the loss of life that is taking place year by year in the working of the coal-mines of this country, but attention to the simplest, oldest, and most common-place precautionary measures. Nor are the evils arising from explosions the only ones we have to guard against; it is alike our duty to pay every attention to the sanitary state of the mines under our respective charges, and to remove, as far as is practicable, all the causes that are either life destroying, or that injure the health of those whose duty calls them to spend a great portion of their time under ground. It requires no argument to prove that a workman is unable to perform the same amount of labour when working in vitiated air, as

when working in good air, and that much of the pecuniary loss thus sustained falls either directly or indirectly upon the employer.

The ever varying circumstances of a mine, and the still greater difference between one mine and another, preclude us from the possibility of determining what are the maximum and minimum quantities of air required for each specified area, or for each workman employed. It is true that anyone understanding the mechanical laws of elastic fluids, may determine with tolerable accuracy the loss sustained by passing a current of air through a mine, and what power would be requisite to put into circulation a given quantity of air under known circumstances. But the quantity of air necessary to ventilate a colliery, so as to render it safe and healthy can only be determined by actual observations as the workings proceed. It is well to be prepared for emergencies by having more air at command than the immediate wants of a mine require, until the narrow work of a mine be fully opened out, and opportunity afforded for the gases to drain from the coal and strata, through which the narrow work has been driven. It may be asked, how it can be ascertained when the quantity of air is insufficient to render a mine safe and healthy. If so, my reply is, that an ordinary person possessed of the senses with which nature has endowed him, can find no difficulty in satisfying himself upon this point, and that those who are unable to do so ought not to be entrusted with the management of a colliery for a single day.

If the means of satisfying ourselves whether a mine be effectually ventilated or not, be as simple and unmistakable as I contend they are, what excuse can be offered by those who continue to direct operations when the safety of the mine, and the lives of the workmen, depend upon circumstances over which the manager can exercise but a very limited control? We need not retrace our steps very far in reviewing the casualities of the mine, to find indubitable proof of the fatal consequences arising from having

more works open at once than the air at command could effectually ventilate. It has been stated that "every coal-mine ought to be ventilated, as if it was an ascertained fact that large volumes of gas would be constantly emitted therefrom." If by this it is implied that all coal-mines ought to have currents of air passing the working-faces of each workman, and that such air-currents be conducted in the most direct manner that the requirements of the mine will permit of, through the maximum-sized air-courses, and at as high a velocity as it is practicable for the workmen to work in, I perfectly agree that all coal-mines ought to be so ventilated. But if more than this is implied, I candidly confess that I do not know what is meant.

With regard to the phenomena of sudden outbursts of gas, I can only speak so far as my own experience will permit me; and as yet I have seen nothing that ought to be designated by such a term. I have seen on different occasions free escapes of gas, that might by some have been called sudden outbursts. Since our last meeting I have seen fifty-four cubic yards of fiery-damp accumulate in a far less number of minutes, and the quantity issuing from one blower was sufficient to keep up a light equal at the least to twenty common gas burners. But when a proper current of air was directed upon it, that portion of the mine was rendered as safe as any other. The only real danger that I can conceive to arise from such escapes of gas, beyond the ordinary risk of working fiery-seams, is by the atmosphere of the mine being allowed to become so vitiated as to be almost at the explosive point throughout the mine, and requiring only the smallest extra quantity of gas to be given off to render it so; the only means of guarding against this state of things that I am acquainted with, is by regulating the extent of the workings by the quantity of air at command and the gas given off, and avoiding having more workings open than can be effectually ventilated. The yield of fiery-damp is influenced to some extent by the

atmospheric pressure, but probably not to the extent that is generally supposed; but at present much remains to be learned upon this subject, and too much attention cannot be paid to the elucidation of it by those who have collected data, or made observations of the effect produced by changes in the atmospheric pressure. It is generally supposed that under all circumstances a fall of the barometer is simultaneous with a free escape of gas in fiery-seams, or in other words, that the fiery-damp previously pent up by an increased atmospheric pressure, whether in the goaf or in the interstices of the coal, is allowed to escape more freely in the latter case, and in the former the body of fiery-damp to approach nearer to the edge of the goaf that the current of air impringes upon. In consequence of the means of detecting the presence of fiery-damp not being delicate or sensitive enough to admit of a satisfactory conclusion being arrived at, I am unable to say whether any exception applies to the rule laid down, that fiery-damp oozes more freely out of the interstices of the coal, when a reduction of atmospheric pressure takes place. But after very carefully noting the effect produced on fiery-damp in the goaf, and other places, by a rise or fall of the barometer, on more than a hundred different occasions, I am compelled to acknowledge that I see no rule that will not admit of many exceptions. In one instance, with the wind from S. S. W., and the barometer at 29·070, and the thermometer at 53°, I found the inflammable gas had approached fourteen feet nearer to the edge of the goaf that the air-current impringed upon, than when the barometer had stood at 30·467, and the thermometer at 51° with the wind almost due south; the same quantity of air was passing on each occasion, as near as could be ascertained by measurement, and the workings and the goaf precisely the same; while in other instances I have not found the slightest possible difference in the approach of fiery-damp from the old workings, when the barometer has fallen more than an inch; and in a few instances I have found it to retreat into the old workings when the barometer has been steadily falling.

It is of importance that as much should be known upon this particular subject as can be, and I beg to suggest that some of our friends who may be better qualified than myself, and who have opportunity, will direct their attention to the elucidation of it.

The velocity at which air-currents can be practicably passed through the workings of a mine, and the loss sustained by passing them through, are subjects connected with the ventilation of mines, that cannot too often be pressed upon the attention of all connected with practical mining. The highest velocity that I find it convenient to pass currents of air past the working-faces of a mine, is two miles per hour, or 2·93 feet per second; and even this is too high a velocity, unless in exceptional cases, where much gas is given off in newly opened seams. It is practicable to maintain a much higher velocity in air-courses where the workmen are not exposed, but high velocities are always attended with much loss of power, the rule being that the drag or resistance is as the square of the velocity of the currents, so that if the velocity be three feet per second in one case, and seven feet per second in another, the drag or resistance would be in the proportion as 9 is to 49; however; this rule is subject to be changed by such a variety of circumstances, that in almost every case in which I have tried to test the accuracy of it the results have been somewhat different. But perhaps it may be correct enough for practical purposes. In order to keep the velocity of the air-currents of a mine as low as possible, and at the same time maintain the mine in a perfect state of ventilation, it is necessary to increase the size of the air-courses to the greatest extent that the nature of the roof and other circumstances will permit of, or to adopt the principle of having parallel air-courses for the intake and outgoing currents of air. The latter system entails a considerable extra expense in driving extra air-courses, and having to maintain them in order, especially in some of the mines in the South Lancashire coal-field. I consider it

highly desirable that all air-courses should be used as waggon roads, where practicable, so as to ensure them being regularly travelled, and maintained at something like a proper size. I again repeat that I know of no single circumstance connected with the ventilation of mines, that is productive of greater mischief than the subject under consideration—obstructed air-courses. The advantage gained by increasing the size of air-courses, or driving parallel ones, is that of allowing an additional quantity of air to pass through in nearly an arithmetical proportion to the increase of the area through which the air passes. It is of importance in the ventilation of mines, that the principle air-currents be conducted through the mine in the most direct manner that the requirements of it will permit of, as much loss of power is experienced by conducting currents of air long distances through the air-courses of a mine. The rule being, that in air-courses of equal section, the volumes of air passing through them are proportional to the square root of their lengths; so that if we had two air-courses of equal area, and one was one hundred yards long, and the other one thousand yards, the quantity of air passing through them, all other circumstances remaining the same, would bear the proportion as 10 does to 31·622, so that if this principle be correct, something less than a third of the quantity of air could only be got through the long air course, as through the short one. In some cases where the workings are very extensive, it is not practicable to reduce the length of air-currents below three or four miles; in other instances advantage is not taken of the opportunity that presents itself to reduce the length that currents of air are often dragged through a mine. In either case, it is not difficult to see the great loss of power that is thus sustained. I have seen collieries, said to be well managed, where the principles of ventilation have been so far neglected as to have the air-currents double the length that there was any necessity for.

It is possible that I may again be taunted with having given

nothing new, very probably I may not have done so, but allow me to say that all the practical principles of ventilation, with which we are at present acquainted, have been known for a considerable time past to a few; but almost every day occurrences prove that many colliery managers either do not understand these principles of ventilation, or that they grossly violate them.

One very important law in determining the correct principles of ventilation, known by the name of Boyle and Mariotte's law, was discovered by Boyle, more than two hundred years ago; and fifty years subsequently to that period, confirmed by Mariotte. Shall we disavow the principles laid down by these eminent men, and cease to act upon them, because they are not of modern discovery; or shall we discontinue the use of that invaluable instrument, the Davy-lamp, because it was discovered some forty-six years ago? Nay, have not two-thirds of the great principles that we are indebted to for our civilization and greatness as a nation been known to the ancients, and lost in the records of time? My object is not, as I have repeatedly stated, that of bringing forward some chimerical and impracticable scheme, but to impress upon the minds of all, whether they be possessed of those rare attainments that some present can boast of, or not, that however much they may know, in colliery management, success must depend upon reducing to practice the principles with which we are at present acquainted; and by the manager, whosoever he may be, or by whatever title he may be known, seeing that those principles are not violated with impunity. It is necessary that strict discipline be maintained in a mine; but, for my own part, I have never found it necessary to maintain a discipline bordering upon that exercised in our gaols, to carry out the regulations of a mine. It, however, may be necessary, in some isolated cases, where factory operatives, day labourers, and others are converted into colliers, as it were by magic-spell, and entrusted and compelled to work with a Davy-lamp,

without any preparatory training in the use of so delicate an instrument.

Mr. E. W. Binney proposed the thanks of the meeting to Mr. Goodwin for his paper,—Mr. J. Taylor, jun., seconded the proposition, which was carried unanimously.

The President having invited discussion on the subject of the paper,

Mr. Binney said that he was glad that Mr. Goodwin was engaged in making observations with regard to the emission of gas. It was possible that with a sudden fall of the barometer gas might not come out, as they should expect. But, nevertheless, he thought that with a great amount of observation, continued over many mines, it would be found that a sudden change of the barometer did on the whole give greatly increased emissions of gas. But this could only be determined by experiment; and he was glad that Mr. Goodwin has set the example of commencing these experiments. He hoped that the attention of colliery managers would be called to the subject, and that they would have a series of such observations, which could not fail to be interesting to the Society.

Mr. Evans, inspector of mines for South Wales, said that the mines in the Aberdare Valley gave off large quantities of gas; but he did not think any observations had been made as regarded the quantity given off under the influence of a falling barometer. They found that the roofs of the mines were so bad that directly the coal was worked away, the roof fell down. All great explosions in the mines in his district were invariably put down to "blowers." There was scarcely a serious explosion unless there

was a "blower." At Risca, where 144 persons were killed, that was said to be caused by a "blower," and people went to hear it, though he must confess that he heard nothing. There was no doubt, however, that "blowers" of gas did frequently occur. He had known them, and very serious ones too. The only safeguard was the proper use of the safety-lamp, together with thorough ventilation.

Mr. Edward Lacey said he thought Mr. Goodwin was rather unnecessarily severe with the colliery management. Those who were better acquainted with the subject could say whether these strictures were just, but they struck him as being rather too severe, especially if what Mr. Goodwin stated was supposed to have the sanction of the Society.

Mr. Binney—I think you should state wherein you find them so.

Mr. Lacey—I cannot exactly recollect the words, but they struck me at the time as being somewhat severe.

Mr. Goodwin—I am here to sustain all the charges I have made, and should be glad to have it pointed out where I have been guilty of exaggeration. It may be unpleasant to go into circumstances which have occurred; however, the force of events may compel it. Again, I may observe that I have consulted some of the most eminent and highly respectable employers of labour; and if they don't think I have been severe, I do not see why those who have less interest in the matter should think so. If the present system is not perfect, let us seek out the imperfections, and endeavour to remove them. I have well considered the subject prior to entering into it. I have no object to serve beyond the benefit of practical mining. It is very unpleasant to make these

remarks; and so it happens that many remarks do not come before the public which I am prepared to make and to prove.

Mr. Evans said he thought he had read in some of the papers that Mr. Goodwin attributed the Risca explosion to the ventilating machine. He (Mr. Evans) happened to be there during the whole of the proceedings, and he consequently knew something about it. The quantity of air supplied was not all that could be produced by the machine. The quantity of air which passed through the mine was about 50,000 feet, the machine working eight strokes in a minute. There was no reason why the machine could not be worked at the rate of eleven strokes a minute, and why the quantity of air could not be doubled. The colliery manager consulted with the engineer, who told him that there was no difficulty in getting double the quantity of air; but the colliery manager said that he had sufficient. The machine had no more to do with that explosion than he (Mr. Evans) had.

Mr. Goodwin—Then to what are we to attribute the fact that there was an explosion?

Mr. Evans—That had nothing to do with the ventilating machine.

Mr. Goodwin—You doubtless remember that it was stated that some of the doors were found to be opened when the water-gauge was examined after the explosion. That was never cleared up; and I think the parties concerned are in duty bound to clear up these points to the public, if only for the sake of their own character.

Mr. Evans—I don't know what you refer to. There was a remark that when some of the men went down into the pit some

one opened the doors. If that is what you refer to, it is all nonsense. If they opened the doors, the water-gauge would not have shewn the enormous pressure it did.

Mr. A. Knowles thought himself that the furnace would in time be found less useful as a means of producing ventilation, and especially when science was brought to bear on the subject, which would be the case when collieries became much deeper and much more extensive than they had yet been. He believed that mechanical power would be employed to ventilate coal mines, and would very likely be found to supersede the furnace very generally. The furnace, as ordinarily used, did very well in many collieries, because it was constant in its action, and even supposing that the furnace had to be extinguished, the ventilation continued for some time after, which was one of the great advantages of it; but with mechanical ventilation there was no reason why they should not have duplicate mechanical power, so that if one portion was out of order, the other could be employed during the time. The disadvantages of the furnace were very great, in the enormous amount of wear and tear in the up-cast shaft. And although this was open to improvement, and it might be so used as to cause less wear and tear, there would always be great loss in the employment of a furnace, in consequence of the smoke and gas given off from the burning of coal at the bottom of the shaft. With regard to Mr. Goodwin's paper, finding fault with the management of mines, he (Mr. Knowles) was sure that no manager was wishful to run the risk of having an explosion at all. In all the instances in which they had occurred, mistakes had been made. The accidents had arisen from inadvertence and omissions, and not from any wilfulness on the part of the managers. There was this certainly to be said in connection with these mistakes, that it was only by things of the kind happening that information was gained. The loss of life was a very sad and mournful event, but the loss of life and property had drawn, and would draw, the attention of the public interested

therein, to the risks which were incurred, and to the finding out of means to prevent them.

The President said he was glad to see Mr. Goodwin's remarks on the management of collieries treated in a more kindly spirit at this meeting than they were at the last. He would be a bold man who would stand godfather for all the managers of mines in Lancashire; but he might say that there were amongst them as good management as was to be found in the kingdom. There were few places where some of the science of mining was better understood; the mode in which the coal was to be worked away, and to keep the weight off the air-courses, were thoroughly understood. But at the same time these things were sometimes managed by people who did not understand them, and who had had no training as colliery managers. They must make a distinction. The remarks made by Mr. Goodwin would perhaps apply to the bad management, whilst those who spoke of the superior management applied their remarks to the good management. In the paper with which Mr. Goodwin had favoured them, he (the President) noticed that Mr. Goodwin doubted the occurrence of sudden outbursts of gas. Mr. Evans had told them of cases where, to the best of his belief, explosions had occurred from sudden outbursts of gas. That "blowers" did happen he (the President) had not the slightest doubt. Some had happened within his own knowledge, and which could only be met with safety-lamps. Another point he should like to make a remark upon was, about the resistance to the movement of air in mines. Mr. Goodwin had stated what was the received law on the point, and he stated that in experiments which he had made he found that the results had not quite agreed with the accepted law. He (the President) should be glad to know under what circumstances the experiments were made, and whether they were made with sufficient accuracy to say that they should throw doubt upon the law. As far as they knew, the careful experimenters had received the law; and

possibly Mr. Goodwin had taken the revolutions of the anemometer, without making proper correction to ascertain the true velocities. He (the President) had, through Mr. Casartelli, optician, an instrument by which he took the friction of revolving anemometers; and also for setting his own (Dickinson's) anemometer, he had taken observations by direct action, his own invention. Many experimenters had not taken the trouble to ascertain what the requisite correction was for their anemometers; and the revolving ones could not be used with any degree of accuracy unless this was ascertained. The late Mr. Biram issued a table of corrections, but that table was the same for every instrument, and they would scarcely find any two instruments agree. In one they would have to multiply the velocity by a decimal, and add a certain number to it, and in another, to multiply by a whole number, and perhaps add a greater number to it, the friction of the instruments being different according to the construction of the anemometer. If there had been any observations so carefully made as to set aside what had been received as these laws, he should be very glad to hear them. The remarks in reference to factory operatives, showed the necessity of discipline when there was often a large number of this class of workpeople who got into the mines, beginning with very little experience, and becoming pickmen almost at once, so that unless they had discipline they never could expect the mines to be conducted with safety.

Mr. Binney thought there was no doubt about the existence of "blowers."

Mr. Atkinson said that perhaps Mr. Goodwin in his next paper would give the Society some details of his experiments concerning the friction of the air.

Mr. Goodwin said he had intimated in his paper that the remarks he had made, and the observations and experiments he

had conducted, had varied in their results in almost every instance, and this probably may have arisen from the causes to which the President had referred. But he had tried the President's anemometer and Mr. Biram's; and he had had the furnace as a motive power, producing a current of air which they all knew was subject to variation, as they could not keep a constant heat. He might state, however, that his object was to throw out the hint that there was not enough known on the subject, and to embolden some one to take it up and give them all the information that could be gained respecting it. For his own part he was at present engaged with experiments, with a view of further investigating the subject. With regard to sudden outbursts of gas, he believed them to be manufactured for certain purposes.

Mr. Thomas Livesey said he did not doubt that there were such things as sudden outbursts of gas, having himself often met with many well authenticated instances.

Mr. Seddon quoted an instance where there had been an outburst in which a report as loud as the bursting of a steam pipe was heard.

Mr. Goodwin said he had never stated that all accidents were actually unavoidable; but he contended that two-thirds of those that did occur were occasioned by recklessness and injudiciousness of some, or the inability of others, who would gladly guard against them if they had the means in their power. He had no object in condemning colliery managers, insomuch as he was one himself. But he felt bound to tell the truth, though he might be revealing some of the secrets of the prison-house.

The discussion then closed.

The following paper, by Geo. Charlton, Esq., Mining Engineer, was then read :—

On the Self-extinguishing and Detector Safety-lamp for Working Miners.

The capabilities of the safety-lamp have won for it the very appropriate Latin motto, "*Moneo et Munio*"—"I warn and I protect;" its province being to indicate the presence of carburetted hydrogen gas, or fire-damp, in mines, and to preserve the workmen from accident, until a sufficient amount of atmospheric air can be obtained to remove the gas from the working-places.

Besides the great care required to fix the exact limits to which open lights may be used with safety in mines producing inflammable gas, every colliery manager in charge of such mines finds another equal difficulty in maintaining strict discipline in the use of safety-lamps in those parts of the colliery where safety-lamps only can be employed.

Many modes of accomplishing strict discipline have been suggested. Education of the colliers has been recommended and tried, but this is a slow process, and the youth of the present must become the workmen of the future, before much improvement can result from this source.

In the meantime many lives may be lost from accidents caused by workmen secretly and foolishly opening their lamps by false keys, which they can readily obtain from the lamp manufacturers in any of our towns in the vicinity of collieries.

As an instance of the thoughtlessness and fool-hardiness of workmen, I subjoin a copy of the Daily Return made on the 28th of May, 1861, by my principal underlooker, which is as follows, viz.:—"*Daily Return made by Mr. William Seddon, Underlooker of the Dunkirk Collieries,* of the state and condition of the Pit Workings, as regards the air, air-courses, lodgements of fire-damp; increase or sudden appearance of fire-damp; cutting through into any old workings; discovery of any of the men unlocking or

injuring the safety-lamps; wilfully exploding any fire-damp, to save trouble or otherwise; or being seen with any kind of naked light where the same is prohibited—stating the names of the men; also of accidents to any of the men (stating the name, cause, and manner of injury received, and whether proceeding from negligence or otherwise); and also of any complaints made by the men, or dissatisfaction expressed by any of them concerning the insufficient state of ventilation, ill condition of the pit ropes, scarcity of prop-timber, or of any other cause of danger connected with their working in the mines."

"28*th May*, 1861.—To-day the ventilation in all the pits has been good, and the work is progressing as usual. But I regret to have to report that one of the workmen in the Astley Deep Pit has evidently had his safety-lamp unscrewed, and his light exposed during his work, for when he left his lamp at the office appointed to receive it, it was found to have a piece of coal nearly the size of a walnut inside the gauze. It would appear that he had had his gauze lying upon his coals whilst working, and then losing his light had screwed the lamp together in the dark without being aware of the presence of the piece of coal. I have not yet ascertained his name, as he has heard of the coal being found in his lamp, and has run from the colliery; but I will do my utmost to discover his whereabouts, so that he may be brought to justice.

"(Signed) WM. SEDDON, Underlooker.

"To the Manager, Mr. Charlton,
"Astley Pit Offices."

Such cases as the foregoing clearly show that many of the accidents that have occurred since Sir Humphrey Davy's lamp was applied to the lighting of mines may have occurred from colliers unlocking their lamps during their work; and we have it in evidence that the recent accident near Wigan, where 12 lives were lost, and at the colliery near to Ashton-under-Lyne, where 41 lives were lost, in 1857; and also at the colliery near the city of

Durham, in 1844, where 95 lives were sacrificed,—were caused by lamps having been tampered with and unlocked by the colliers during their work in the presence of inflammable gas.

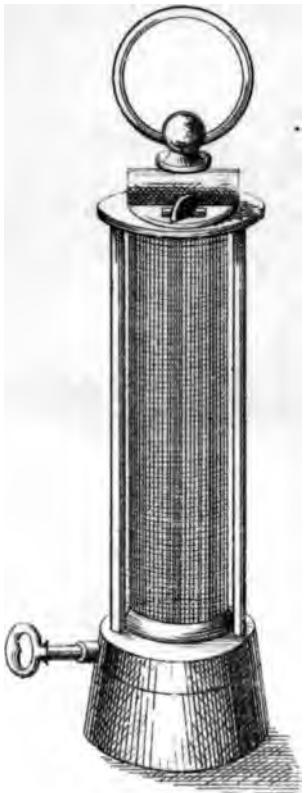
Several valuable additions have been made to the Davy-lamp, to render it more safe, and self-extinguishing; and also to have the poles and oil vessel locked together and stamped on lead with a die each time they were attached; or the locks sealed by other contrivances. But the complexity of their arrangement, and the expensiveness* of their construction have hitherto prevented such improvements from becoming generally used.

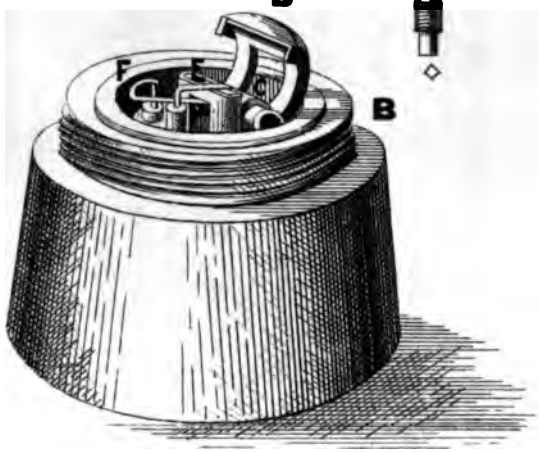
During the present year, Mr. Jones, of London, and myself have been closely engaged in inventing a piece of mechanism of great simplicity, which can be readily adopted in any Davy, Stephenson, or Clanny lamp; so that what good discipline fails to effect our mechanical appliance does instantly and unerringly accomplish, by causing the workman to extinguish his own light the moment he attempts to open it; and so removes the inducement to tamper with his lamp.

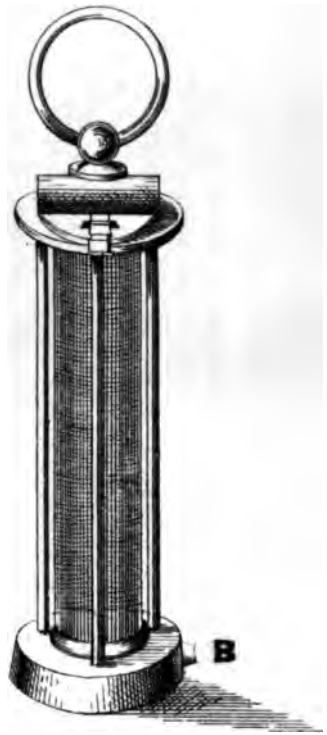
The invention consists in removing the ordinary lock from the bottom, or outside rim of the lamp, as shewn upon the accompanying drawing, and passing a screw bolt, marked A upon the sketch, through the brass rim, B, and also through two small pillars, C, firmly into an extinguisher, D, to a point where it is securely locked. While the *bolt* is being turned from left to right to lock the lamp, it gradually turns the extinguisher, D, to the right side to form no shadow; but the moment the bolt is turned back from right to left to open it, the extinguisher is infallibly brought upon the flame, and instantly puts it out.

To prevent the ingenuity of a collier raising the wick above the extinguisher to prevent its action, two pickers, E and F, are

* *Vide*—Trans. N. Eng. Inst. of Mining Engineers.—Vol. 2. p. 54.







DRAWINGS OF

Messrs. Jones & Charlton's

PATENT SELF-EXTINGUISHING & DETECTOR GAS[illegible]

placed in the oil vessel—E to sweep over the surface of the wick to remove the snuff, and F to raise the wick one-fourth of an inch, but no further. And we find that with wicks made of woven cotton, one-eighth or one-sixteenth of an inch is sufficient for an ordinary day's work and use.

Besides the above additions, an improved burner has been introduced into this lamp, by which nearly double the light emitted by the ordinary Davy is produced.

In conclusion, I have to add that in my own experience those colliers who would so open their lamps are an exception to the general rule; but if there be only one or two such workmen in a colliery, they might cause serious accidents, but such an arrangement as herein described would always prevent accidents arising from such a contingency, and, moreover, miners would no longer be tempted to tamper with their lamps, as they would then be at once detected.

Mr. A. Knowles proposed a vote of thanks to Mr. Charlton,—Mr. Goodwin seconded the proposition, which was carried unanimously.

Mr. Goodwin expressed a doubt whether colliers were made into better workmen by education.

Mr. Atkinson suggested that the reason was, that they did not get enough of it.

The President said it was desirable that the locks of safety-lamps should be as simple as possible. Complicated locks, such as Chubb's would never do for a safety-lamp. Mr. Wareing, of Neath, had a patent lamp similar to that now exhibited; and which, on being exhibited before the South Wales Institute of Engineers, was opened by two or three persons in succession without unscrewing. There was a slight difference between the one now exhibited and Mr. Wareing's; in this the picker was intended

to act only once, so as only to push the wick up to a certain point, at which it was covered by the extinguisher when turned down.

Mr. Charlton said that these and other points had been carefully and closely investigated. He quite agreed that Mr. Wareing's lamp was an improvement upon the previous lamps, and there had been inventors who had made improvements since; but they all failed from their complexity. He believed that an extinguisher, with the pickers preventing the wick from being pushed up too high for the extinguisher to catch it in coming down, was all that could be required to prevent men opening their lamps during their work. With regard to education, he might state that his own experience was, that colliers, and every one else, were all the better for having a good education. He did not think that education itself made men dissatisfied; the better the education the better for both physical and mental labour. With regard to another point mentioned, namely, the existence of gas at all in coal-mines, he would remark that in collieries where gas was produced at a rapid rate, and especially where ventilation could not possibly sweep away the gas from the edge of the old works or goafs, it was highly desirable to have lamps perfectly good and safe. Good ventilation and strict discipline must ever be attended to; but at the same time it was a great point gained to make it impossible for a workman to open his lamp without extinguishing it. It had happened that in a moment of temptation, a man had unlocked his lamp, and at the instant there was a sudden fall of stone in the goafs, and all that was left to tell the tale, was a disjointed safety-lamp, as had been the case under his own observation, not under his own management; for he was happy to say that nothing of the kind had occurred under his own care. But at inquests he had attended, he had found cases of this kind, and it was out of pure benevolence to the mining population that he had exerted himself in the matter, and he hoped that for the future they should have no accidents arising from that source.

This closed the proceedings of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 10.] [Session 1861-62.

ORDINARY MEETING, *Tuesday, January 28th*, 1862.

JOSEPH DICKINSON, ESQ., F.G.S., President, in the Chair.

Mr. J. Taylor, Jun. exhibited some flint implements received from Lake Erie, now used by some tribes of the American Indians, and similar to those now found in the drift. One of the flints appeared to have been used as a spear-head or arrow-head. They resemble also some shown some time ago by Mr. Darbishire, from the drift.

Mr. Binney drew attention to two specimens of Lepidostrobus, (*ornatus* and *comosus*,) presented to the Society by Mr. Joseph Goodwin. He would, however, suggest that in future donors should not varnish such specimens, as they were almost spoiled by it.

The thanks of the Society were voted to Messrs. J. Taylor, Jun. and Joseph Goodwin.

Andrew Knowles, Esq. being called on by the President, read the following paper—

On the Bank Top and Hagside Pits; and the Proving of Faults.

The Bank Top Collieries are about one mile from the town of Bury. One shaft or pit adjoins the East Lancashire section of the Lancashire and Yorkshire Railway, and is connected with it by a siding; the other is on the bank of the Manchester, Bolton, and Bury Canal. To the mine, the former pit is 130 yards deep, the latter 160.

The mine worked is generally supposed to be identical with the Rushby Park of St. Helen's, the Arley of Wigan, and the Royley of Oldham. Although I have not very earnestly endeavoured to discover which it is, I am, however, inclined to think it is identical with those named. At some future day no doubt it will be known with certainty which position it occupies in the Lancashire Coal-field.

The Hagside Pit is 760 yards to the deep of the one that adjoins the railway; being 280 yards in depth to the coal, and 300 to the bottom of the sump-hole. It is 11 feet 3 inches in diameter. It is used partly as a pumping pit, the engine employed for the purpose being a vertical or direct acting one, and capable of working up to 200 horse power. The cylinder is 63 inches in diameter, with a 9 feet stroke. The water is raised by two force lifts, the lower one is 150 yards long, the higher one is 145; the former ram is 15 the latter 15½ inches in diameter; there is also a small ram 5¾ inches diameter, 100 yards down the pit; altogether the engine lifts at each stroke about 34 tons of dead weight. The pit is also used as a downcast to ventilate the Bank Top Collieries,

which are both upcasts. The ventilation of the mine is produced by the exhaust steam from a pair of 20 horse-power engines, employed to work an incline, at the bottom of the pit, on the railway side, assisted by a furnace which is there also, and by the exhaust steam from a pair of 12 horse-power engines and furnace at the bottom of the pit situated on the canal bank; the engines in this case are likewise employed to work an incline. In both cases, when the steam has passed the engines, it blows out into the pits, without any obstacle to its egress. Several attempts were made, at one time, by my direction, in the way of adopting a system of steam jets, but they were found not to answer; all that we now have is a partition to prevent hot water or steam from being sent into the cages when the engines are working, and men are descending or ascending the pit.

There is nothing of particular Geological interest in connection with the mine, more than is usually met with in coal-mines. We find in a layer of strata, about four inches above the coal *anthracomya*, and in the formation between a bed of coal called the two feet coal and the main bed, I have seen several good specimens of sigillaria. These strata vary from three feet to seven yards in thickness. The average thickness of the mine worked is four feet six inches, but there is this peculiarity in one part of it, at the lower side of a place where the dip is the greatest, that the mine is there about six feet thick; and the two-feet coal is thicker than it is found in other parts of the colliery. For many years before, and several years after 1850, the coal worked at Bank Top was principally that to the rise of the pits, and as this coal was then becoming exhausted, we commenced to re-open by driving a down-brow in the mine, to the deep of the pit. In the following year, 1851, I cut the first sod of the Hagside pit. When we had driven the downbrow 660 yards, we came to a fault, which was soon proved to be a downthrow; we tried to prove the extent of it by following the vein a little distance, but we found it was a large one

and gave up this means. We then drove a tunnel a few yards straight in, and from this point we bored a hole until we crossed the fault-vein without meeting with the coal. We followed the same course a few yards further with the tunnel, bored again and found the coal at 26½ yards in depth. Having found it, we returned to the beginning of the tunnel we had driven, and commenced another with a dip of 1 at 1, we worked shifts night and day; it took several months to reach the coal; the tunnel was 48 yards long. When found, the coal was of the usual thickness, the usual dip, and, to all appearances, free from any more faults; but after driving 17 yards down the mine we came to a large upthrow. To prove this, we drove a tunnel straight forward, about 12 yards; from this point we bored a perpendicular hole upwards, which we supposed crossed the fault-vein, as was afterwards proved to be so; we then returned to the vein and climbed up it to the distance of 23 yards in perpendicular height, to where we found the coal. After taking the levels, we found that a tunnel driven, with a dip of 1 at 6, from where the coal first broke off to where it was last found, would recover it; we drove the tunnel which met the mine in its full thickness; the tunnel was 92 yards long. From the end of it we drove a level in coal to where the Hagside pit would be when it was sunk.

While the above was being proceeded with, we were also going forward with the sinking of the Hagside pit. We had a drift deposit, composed of sand, loam, and pea gravel, full of water to go through, and which was 33 yards thick to the solid. This took some time to sink through and make good, so that the brick work round the pit would keep back the water. After reaching the solid, we continued sinking the pit until we arrived at the coal, with the exception of the time occupied in making lodge room to hold the water made by the springs met with in the sinking. When we got to the coal we drove a downbrow in it to a fault which was proved to be a 3½ yards downthrow. This caused us to

sink the pit lower, with the view of tunnelling out to the deep, which we did, the tunnel being 40 yards long. At the end of the tunnel we found an upthrow fault, and from this point there was a change in the position of the strata, the measures rising at the face instead of dipping in the usual way. To prove the ground, we drove a tunnel forward, and also one from the bottom of the sump-hole in the shaft 12 yards lower, and nearly parallel with the higher one; this was driven partly to afford lodge room for water, and likewise that we might have the strata in each to give us the knowledge of the relative position we were in to the coal, that if we did not know the strata in one we might in the other. After driving 120 yards, some of which was in very hard rock, we came to a large upthrow fault. We went 15 yards through the vein and found a change in the measures, the dip then being the right one, but we were in strata we had never seen before; consequently, we had no idea whatever as to how far we were below the coal. Having ascertained where the measures dipped, in the usual way, we returned to the point at which we left the coal, and then went up the mine to the large fault we had driven to; when we got to it, we climbed up the vein until we reached the coal, which proved it to be a 66 yards fault. We now knew the size of it, but nothing about the coal. To ascertain this, we drove a tunnel to it, with a rise of 1 at 1, the place we had made up the vein having come together, which occasioned the necessity to drive a tunnel; this being done in the solid. From the top of this tunnel we drove a downbrow in the mine, 120 yards long; the coal lay in its regular position, of the usual thickness, and of good quality. To enable us to make a further proof of the coal, we drove a tunnel to rise 1 at 3¾ from the end of the pit one to it, which was 131 yards long: so that after sinking the pit to the coal, we had to drive 307 yards before we could proceed with driving a level in it. We drove a level in the coal, and obtained the extent of some faults in another direction in fresh ground; altogether, the information gained proved a sufficient breadth of land for our purpose.

In giving my opinion in connection with the proving of faults, I shall confine my remarks to the kind commonly met with in the Lancashire coal-field, not having had practical experience with any other. The faults generally met with in this country, are dislocations, whether they are large or small ones; I mean by this that the strata are broken up, and that the coal and other measures are often found the same on each side of the fault-vein. The dislocation appears to have been effected by some cause which has not altered the thickness of the strata, or changed their nature. To describe the manner in which I would recommend those engaged in mining operations, to proceed in proving faults, I will suppose that the workings of a colliery require extending in a certain direction, in unknown ground, and that after proceeding in the direction to a given point, a fault is met with. It is easily known whether it is a down or upthrow; if the former, the coal not unfrequently dips a little, for a short length, before you arrive at it; if the latter, it often rises to it. But supposing you arrive, without any previous indication, at a fault, the direction is generally known by the way in which the striæ, or two sides of the fault-vein, commonly called the "slippy partings," point. If a down fault is met with, the direction is away from you, if up, you touch the vein first at the floor of the place you are driving. I will suppose the throw to be down; in this case, if the fault is found in a level that has been driven to it, I think the best way to prove it, is to go down in the vein; in doing so, it is necessary as you proceed to lay it bare on the furthest side, to be certain not to pass the coal, for if the two sides of the fault happen to widen out from each other, the fissure being filled up with *debris*, forming a kind of conglomerate or aggregation of crumbled strata from above, it is possible to go by it, this material hiding it from view. When the depth of the throw is ascertained, a tunnel to the rise, in a direction that will keep you quit of the fault, will bring you to the coal again, where you can proceed with your level; the length of the tunnel will depend upon the depth of the throw, the dip of the

mine, and the angle of the fault. If a fault is met with in driving a downbrow, and it crosses the place driven diagonally, the best way to prove the extent of it, is to go down the vein at a right angle, to the side of the brow, until you find the coal; it will depend upon which side it is found whether the offset would have to be made to the right or left hand. In proving upthrow faults, I think that if there is much coal left in driblets upon the ledges or steps forming the vein, and which gives off fire-damp, that it is the best to take two places up parallel with each other, and so near together (supposing the nature of the ground will admit of it) that cut-throughs can be made easily, at short intervals, from one to the other; the following advantages are also secured by taking this course.

Firstly—You ensure better ventilation.

Secondly—If when you get a long way up, say 30 or 40 yards, and one of the places happens to come together, or the timber sprags set to keep the sides good, give way, there would still be a road out for the men employed at the top of the hole.

Thirdly—When the coal is reached, it can be more effectually and rapidly proved than with one place.

Fourthly—The clearing away of the smoke, when powder is used, and there being a place of refuge, close at hand, when shots are fired, thereby preventing the necessity for the men to come out every time they fire them.

Speaking in a general manner of the proving of faults, I think the two main points to be kept in view, are the making the ground good as you proceed with the work, not to sacrifice having the road made safe and secure to speed; and the being very particular in having the sides of the vein on which you expect to find the coal laid bare, so as to prevent the liability there is to pass it,

which has been before alluded to. In sinking or tunnelling through very hard strata, it is better to use steel drills, than drills made of iron, with the cutting part of steel. It is found that the blow from the hammer tells more effectually in boring when the drill is all steel, than it does when partly made of iron; the iron apparently gives way under the force of the blow, whereas with steel the force is expended in cutting the stratum upon which it is acting. In boring through very strong ground, it is not necessary to have the drill very sharp or even remarkably hard, but tempered so that the cutting part is tough, and will stand, without splintering, until it is worn dull, which it will not do if it is brittle.

The following are some of the technical words used by colliers, when speaking of matters connected with faults. Sometimes close to a fault, the coal is crushed almost into dust; it is then called *suddy*. When, in proving a fault, the coal is found, it is said to *board*. In some cases when approaching a fault the coal is harder than usual, it is then called *wooddy*. A very hard fine grained brown rock is called *bur*. Ordinary rock also when near a fault is sometimes contorted, which makes it worse to blow with powder, in this case it is called *lindsey*.

In the working of a colliery which is situated in a district where the ground is very much broken up, the working expenses to be incurred in producing the coal are heavier, and the danger attendant upon working the mine greater than where there is clear coal to work at. There is also the risk in proving new ground, that is, faults, of meeting with water in some of the veins. These are the disadvantages of faults. Of course, as a rule, the largest quantity of coal is got from clear ground; but there are few collieries that are not troubled with faults more or less. I have seen very few plans that have not had some marked upon them, or that have not shewn the workings to have been stopped either in one

direction or another through the meeting with a large dislocation or a number of small ones, which have acted as a bar against further progress.

I think faults, in most cases, decidedly do two things. In the first place,—in many instances they form an effectual barrier against the nearer approach of water. In this respect, at some future period in the history of coal-mining, the utility of them may be discovered; for when all the coal is worked out to a great distance down every mine from the out-crop, they will be very valuable, if it is found that they are the means of preventing the water from descending to where it would be more difficult and expensive to deal with, than where it is nearer the surface. I do not think the cutting of them in many places will interfere with this, for when the coal is got all round the place where they have been cut, and the water is allowed to remain at rest, the apertures made will soon be closed up by the falling in of the strata, and the deposit of sediment from the higher part of the mine. In the second place, they keep the gas in the coal. If a mine has not much gas in it, where it is near the surface, the same mine may be well charged with it to the deep of a fault running parallel with the out-crop of it, the fault having the effect of keeping it in. Under these circumstances the coal is generally better and freer to get, owing to the gas splintering off the coal, thereby assisting the miner's pick. In my opinion no conclusion as to the cause of faults can be arrived at from the knowledge of a few local ones. I think one of the means by which the Geologist will be able to obtain a clue to their origin, is the information furnished by all the main faults in a county being laid down on the maps of the Geological Survey.

The thanks of the Society were given to Mr. Knowles for his paper.

The President then said, I see a great many colliery gentlemen

present, and I should be glad to hear any observations, for it is not often we are favoured with such a very large attendance. The only reason, I think, why some one else has not commenced the discussion is because there are so many points in the paper that you have not decided where to begin. I may, perhaps, set you the example, by introducing one of the first points, which Mr. Knowles has started, and that is the identity of this coal in the Lancashire section. I know there are some gentlemen here who have some doubts whether this Bank Top seam is identical with the Royley or Arley mine in this county, or whether it does not occupy a higher position in the series. The coal formerly worked at Fern-hill, and now at Seed-field, near Bury, and known as the Dogshaw seam, has been admitted to be the Royley mine, but doubt exists as to whether this is identical with the Dogshaw mine, although Bury is within two miles of the Bank Top pits. The section of the seams bears a striking resemblance, the thickness of each part of coal, and the thickness of the strata intervening, are the same; but there is a difference in the granular structure of the coal. If they are not identical, to what seam does this Bank Top seam correspond? I know of no other that it could correspond with, except it be the mine known as the Cannel Mine, which, although not cannel in this part of the coal-field, the seam may correspond with that position. I don't wish to commit myself to an opinion at present as to which of the seams it belongs to.

Mr. E. W. Binney—Mr. Knowles guards himself against giving an opinion, and I think he does perfectly right. It is a point that will bear a great deal of discussion. I have looked over the ground myself, and I am inclined to coincide with Mr. John Hall, who decided that the Hinds Mine was a superior seam to the Dogshaw, 50 years ago. He has told me he could prove it by natural sections. I have examined a great deal of his work, and I have never found him wrong in any statement yet. Until some gentlemen have worked at this matter 40 or 50 years, as he has done,

I should be inclined to coincide in his opinion. I have thought it would be a good subject to go and fight out on the place. If we could go to Bury, and look at the ground, and all the local evidence, we could perhaps come to a conclusion. I am only expressing my view, which is chiefly based on Mr. Hall's opinion, that this is not the Arley or Dogshaw seam. This paper is very valuable, especially as to the faults. Geologists lay faults down with rules, and I have been accused of that myself, but there are interesting faults here; and if every coal proprietor would come forward as the Messrs. Knowles do in this instance, we should get some practical knowledge, and we should not be so much inclined to draw the faults in straight lines. I do hope that this example will be followed, and that the coal proprietors will come forward and occupy their proper position in our Society.

The President—In endeavouring to determine whether this seam is the Dogshaw or not, perhaps Mr. Knowles can tell us what has been done with regard to boring underneath.

Mr. A. Knowles—The deepest boring under it was at the Hinds Colliery. The boring was 69 yards, when the water came in and prevented the work going on. The next proving was 66 yards under it, at Hagside, but there was no coal. With regard to the chasm represented in the fault on the plan, the coal which would have made up the longer length has been lost in driblets down each vein. In going up the vein you pass small driblets of coal.

Mr. George Charlton—I was going to say, with regard to that point, that whilst the subsidence was taking place the strata might have been moved longitudinally. In the very valuable paper which Mr. Knowles has read, he speaks of the faults forming natural barriers for water, and also as retaining gas in the coal. I believe it is also exceedingly valuable to have the faults made use

of as natural divisions in ventilation. The faults may prevent the destruction of the ventilating power.

The President—Do you think, as a rule, the strata is much changed on crossing a fault? Mr. Knowles says, in these Lancashire strata, it is pretty much the same on one side as the other.

Mr. George Charlton—As a rule, with smaller faults, the strata are not changed; with larger faults they are very much changed.

Mr. Binney—I have seen, especially on the coast of Fife, soft substances in the measures, which, when you get near to the faults, become very hard. The movement of the strata seems to have generated so much heat as to have hardened the sides of the fault.

The President—That a fault does disturb the strata near to it is to be observed in almost every case, but it is only for a very short distance from it.

Mr. Binney—There is no doubt about faults being dislocations of one portion from another, but the mere occurrence of a fault will not change the strata, except by pressure, or infiltration of mineral matter, or something of that kind.

The President—Some of the other points raised, as to the tools best for boring, are highly important. Ordinary iron does not produce so good an effect as the best iron when the iron is tipped with steel; and Mr. Knowles says a drill made entirely of steel produces the best effect.

Mr. Francis Charlton—There is no doubt of that, sir. We have found steel drills a great deal better than iron ones.

Mr. George Charlton—There is some of the stone which is met with in boring that could not be cut through except with steel drills. Although these drills are more expensive in the first instance, we find they save us a large sum of money in the end.

The President—I suppose it arises from the greater density of the steel, or its more compact structure.

Mr. Goodwin—I have adopted the use of steel drills, and find them better and more economical than the iron ones tipped with steel.

Mr. George Charlton—Whatever force is given to the outer end of a steel drill is carried directly to the stone without losing any power.

Mr. Wynne—If you hold a steel bar in your hand, and strike it, the jar in your hand will be greater than if the bar was of iron.

The President said that he should not like it to go forth to the public that what Mr. Knowles had said with regard to keeping back water by the apertures becoming closed by the falling in of the strata, and the deposit of sediment, was to be relied upon in all cases, for he believed some of the most serious inundations had arisen from that cause.

Mr. Knowles mentioned an instance to support his view, and added that much depended upon the nature of the strata where the fault was cut. If the water in a mine was allowed to remain at rest, it would deposit a sediment at the lowest point, which in time would become very hard, and, along with the fallen strata, would eventually choke up any passage that had been made.

The President—Would you like to trust to it without boring?

Mr. Knowles—Not under all circumstances.

In reply to the President, Mr. Thomas Watson, head underlooker of the Hagside Colliery, and Mr. George Peace, both expressed themselves in favour of steel drills. Mr. Peace added that with regard to faults, when they were near the surface they were more liable to let the water through than when they were very deep.

Mr. William Blackburne—I think there is no second opinion as to the advantage of steel drills over iron ones. Sinkers often have an understanding that they are to be supplied with steel drills.

Mr. Joseph Goodwin then read the following paper on

The Ventilation of Mines.

Mr. President and Gentlemen,—Owing to some misunderstanding, notice has appeared in the Society's circular of my intention to read a paper at this meeting, the first intimation of which reached me on Saturday morning, since which time pressure of business has prevented me from bestowing any time in the preparation of it, beyond what I was enabled to devote to the subject yesterday evening. I, however, hope that the discussion following the reading of the paper will somewhat compensate for its incompleteness.

I may first observe that my promised paper on the safety-lamp and its uses will still be due to the Society. As the recent catastrophe at the Hartley New Pit has called forth the sympathy of almost every subject within the British realms, and appears at the present time to be exciting the minds of all engaged in the trade, it may not be out of place to consider how far it is

safe to trust to a bratticed shaft for ventilating coal mines. The system of working a colliery with only one shaft presents an unfavourable aspect, viewed from whatever point it may be; but probably the system is more at fault, in so far as it affects the ventilation of a colliery worked upon this principle, and the risk to which it exposes both employer and employed, than if viewed from any other point. If we take the Hartley New Pit as a type, we find a colliery employing from 200 to 300 workmen, at a depth of 200 yards in round numbers, and having only a 12 feet shaft, divided by bratticing, and containing pumps, &c. &c., from which a third of the area may be deducted for space occupied by pumps, bratticing, &c., leaving only 75½ feet area for both upcast and downcast, or what is nearly equal to a shaft 9 feet 10 inches in diameter, which, equally divided, leaves an area of 37 feet, or two shafts, each 6 feet 11 inches in diameter, out of which space the cages work both up and down, a circumstance which must impede the progress of the air to a very great extent. I have on different occasions noticed the effect produced by each descent of the cage where the principle is practised of having only one rope in each shaft, or division of the shaft, and have found that, on each descent of the cage, the air was temporarily suspended. I have seen this effect produced where 13,000 cubic feet of air were passing per minute, in one current, at more than 100 yards from the shaft. If an explosion should take place where this system is practised, what hope is there for either the safety of the workmen or the employers' property? If, as at Hamilton Colliery, the furnace be used, and the brattice take fire, the same blank hope for the safety of either property or workmen presents itself; and this is a contingency that requires the most extraordinary precautions to guard against where this system is employed, and the furnace used as a ventilating agent. If an unlooked for occurrence presents itself, as in the present case, what human power can render assistance to the unfortunate victims of such a system? Against these objections I do not see a solitary advantage arising

from this system of working a colliery, so far as the ventilation of mines is concerned.

In connection with the Hartley New Pit catastrophe, it has been frequently remarked, in the newspaper reports, that the carbonic acid gas had risen to the highest point, and that hopes still existed of finding some of the men alive. Having heard the probability of this circumstance occurring denied by many well-informed persons, I deem it no digression from the subject to state the result of Dalton's experiments upon the diffusion of gases. He says, "When a light and heavy gas are once mixed they do not exhibit any tendency to separate; in this respect they differ from mixed liquids; and that if two vessels are placed one over the other, and connected with a narrow tube, and the upper one filled with a light gas, as hydrogen, and the under one with a heavy gas, as carbonic acid, an interchange speedily takes place of a part of their contents, which their relative positions might be supposed to present. Contrary to gravitation, the heavy gas ascends and the light one descends, until in a few hours the two become perfectly mixed, and the proportion of the two is the same in both vessels." Passing over this part of the subject, we will next consider whether a shaft, of the limited area of 37 feet, is capable of allowing a sufficient quantity of air to pass through the workings of a mine to render it safe and healthy, assuming that 400 feet per minute is required to effect such purpose,—a quantity below that fixed by some of our mining engineers. For 230 men 92,000 cubic feet per minute would be necessary, which would require the velocity of the air-current in the shafts to be 2,486 feet per minute, or more than 41 feet per second. Is it to be supposed that such a velocity can be maintained under any circumstances, much less when it is considered that a furnace was the motive power, and that the coal had to be raised up a shaft that would only be considered in many localities as large enough for a pump well? I do not consider that 400 feet of air per minute, for

each workman, is more than is necessary to maintain the sanitary state of the mine under favourable circumstances; but, as I have before stated, the effectual ventilation of a mine depends upon such a variety of circumstances that it is almost impossible to fix a maximum quantity of air for mines under some circumstances. Some of the highest authorities have condemned this system of working a colliery with only one shaft; amongst them we find the names of the illustrious George Stephenson, and the warm-hearted miner's friend, James Mather. Stephenson remarks, in a communication to the South Shields Committee on accidents in coal mines, "That the ventilation of coal mines would be much more certain if two pits were sunk instead of one; and that a much better, and, in the end, a much cheaper ventilation would be carried on by having two pits instead of one." Mr. Mather, whose remarks are entitled to the fullest consideration, in giving his report of the Burradon explosion, says, "There is, however, a certain and specific cure, which, well applied, would remove the evils of Burradon. A new pit to the rise seems to be essentially necessary for carrying on these workings with safety and success. Its cost will probably be the cheapest way of working the mine. Sooner or later this measure will require to be had recourse to, and better soon than late." The South Shields Committee on Accidents in Mines, in its report, as reprinted by the House of Commons, states, "That the imperfect state of ventilation in the northern mines is caused by so few shafts in proportion to the extent of underground workings, and in no case ought there to be less than one ventilating shaft apportioned to at the least every 40 acres; and that no winning or extraction of coal in a new mine, should be allowed to be made unless two distinct and separate shafts have been previously put down, which should be procured by Act of Parliament." These are not the only weighty authorities who have condemned this system of working a colliery, and, without seeing a single paragraph written against the system, I have denounced it on many occasions during the past

year, through a thorough conviction that it not only immeasurably increases the risk to both employer and employed, but that, pecuniarily considered, no real advantage occurs from this system of working a colliery.

As my views do not appear to be clearly understood in reference to sudden outbursts of gas, I beg you will pardon me briefly bringing the subject before this meeting. What I wish to state is, that sudden outbursts of gas, so far as I am aware, have not been found when the mines wherein they have been said to occur have been newly opened, or in driving the narrow work which, from all we yet know upon the subject, should be the time when these sudden emissions of gas take place. Is it not a well-authenticated fact that there are mines worked upon principles which go far to convert the old workings, passed and re-passed by the miners many times a day, into a series of huge gasometers? I have myself seen coal worked out, commencing near to the shaft, and leaving only one pillar above the waggon road for several hundred yards, and the boundary of the workings not reached within some years of the time of converting the workings near to the shaft into a goaf, which the workmen had to pass and re-pass many thousand times. I can understand how a fall of roof, or a decrease of barometrical pressure, would allow the subtle and deadly enemy, fire-damp, to be forced upon either the working faces or the waggon roads where such principles are acted upon, but I do not think such occurrences ought to be designated as sudden outbursts; and I beg to suggest not only to this meeting, but to all that may see my remarks, that every scrap of information bearing upon the question of sudden outbursts of gas be duly and fairly authenticated, with the particulars of all the circumstances by which they are accompanied—the quantity of air passing at the same time—the state of the workings—and the amount of barometrical pressure. Such observations would be of service, in guarding against such occurrences; and data sufficient

might be collected to enable us to understand more clearly what is meant by the employment of such a vague and indefinite term as "*Sudden outbursts of gas.*"

It may be contended that owners of collieries are the best judges upon the question as to the number of shafts required, and the system of getting coal to be employed. For my own part I would not dispute such right were those who worked upon such principles the only ones to suffer; but when those who are desirous of working upon a better plan, and who spare no expense to give security to the workmen, and afford greater protection to their own property, feel so acutely the effects of the misdeeds of others not so disposed, it becomes a question upon which all have a right to speak, and to use their efforts to put an end to a system so fraught with disastrous consequences.

The thanks of the Society were given to Mr. Goodwin for his paper.

Mr. Binney—I have heard this system of trusting to one shaft condemned for twenty years. Some two years ago I was advised to sink a shaft 100 yards deep with a brattice, but I would not have the responsibility on my conscience if any accident happened, and I refused to do it. If a fire took place some of the men might escape, but it would be a miracle if they did so. I doubt whether one shaft is cheaper than two. Setting 100 or 200 acres of coal, a pair of pits would be cheaper in the end. In Scotland, where you see a great number of these brattice pits, the repair of the brattices is a constant source of expense. Mr. Goodwin has mentioned these outbursts of gas. I do hold that there are places in the rock within two or three feet of the seam of coal, full of fissures containing a great amount of gas, and that the gas will remain in the rock so long as three or four feet of the metal between it and the top of the rock remain intact, but as soon as that metal falls gas

will come out. It is an awkward thing to state a general conclusion, but I believe that gas does come out of these crevices in rocks, and it has been proved over and over again that it does come out. I think Mr. Goodwin himself will admit that there are cases where gas does come out of faults. I think at the last meeting he hardly contended that there was no such thing as gas coming out of a seam of coal.

Mr. Goodwin—No.

The President—As this sad business at Hartley has been alluded to, I may say that it will be satisfactory to you to know that the government are before the public, and that they have already made full arrangements to ascertain to what extent these bratticed shafts prevail; and in the course of a few days they will know the number of brattice pits that are in the country; pits with only one entry I mean.

Mr. John Fletcher—I see some newspaper lays the blame on the inspector of the district; but I think it is not right to lay the blame on him, as if he was responsible for all accidents.

Mr. Binney—I think it is very unfair to make any reflections on the inspector.

The President—No doubt the system of brattice pits has received the sanction of eminent mining engineers, but I have always been an advocate in favour of two shafts. That a large body of men should be sent down to work with only one entry is what I have always endeavoured to put a stop to, and in some instances I have been successful. At the same time, it does not do for the inspectors to insist too dogmatically in the matter. If the inspector were to say, "I will have the brattice pit done away with," he would not be so successful as if he were to make a

quiet recommendation to that effect. The newspapers to which allusion has been made state that the inspector could have referred the matter to arbitration, but at the same time we know how unsatisfactory that is to the inspector. The arbitration clause is not such as the inspectors wished to have or that the government proposed; it is such as they could get. The nomination of the arbitrators is in the power of the coal owners. As to restricting the workings to 40 acres, for one shaft, as has been suggested, I think that could not do for the north, where there must be much larger tracts worked than that to remunerate the proprietor. Now about these outbursts of gas. At the last meeting some persons denied, *in toto*, that any sudden outbursts of gas ever took place, and others spoke of cases which came under their own personal observation. For my own part I was for years in the habit of daily going into mines before an outburst ever came under my notice, and I dare say that I was then as sceptical as Mr. Goodwin. I have since had on different occasions occurrences of outbursts of gas so evidently under my notice that there could be no question whatever about it. Within a few days after our last meeting an outburst of gas occurred, which although I did not see it, I heard the evidence of all the men who did see it. It happened in what is called strait work. It was in the Lower Bent mine, at Hollinwood. The coal was reached by a tunnel from the Black mine, the tunnel starting only 48 yards from the bottom of the downcast shaft, was about 350 yards long, the level in the coal then going along a distance of about 300 yards, with a free, uninterrupted flow of fresh air, with no workings whatever, with the exception of what was between the two levels, and an airbrow at each 100 yards. These levels having been driven out for 400 yards, it was found desirable to make one of them into a horse way, and there being about ten yards between the two levels that coal was being taken out of, and the rubbish stowed in the place of the coal, so that there was a clear space of coal removed, and stowed with rubbish, of 14 yards in width, that had been taken out for 300 yards in

length. Safety-lamps were in use in other parts of the workings, but here, the underlooker had allowed candles, as both sides were the main intakes for fresh air. The men were at work, when a great noise was heard. A man said the whole place was coming in, and the description given by the others was that it was like an earthquake. The timbers were suddenly snapped in two in the middle, and, before the men could move, the gas burst up from the floor, and lighted, for above 30 yards in length. The flame burnt for half an hour, but was finally put out. On examining the mine myself, I could come to no other conclusion but that it had taken place exactly as they had described it. There was an excellent current of air, amounting to 8670 cubic feet per minute, 4930 of which was in the upper level where the outburst took place, the remainder being at the lower side. That is the only blower that I recollect in my district during the last twelve months.

Mr. Wynne—I quite agree that blowers are often made an excuse for bad ventilation; and I can myself bear witness to outbursts of gas coming on when they are least expected. I know of one instance where there is a good seam of coal being worked and a very thin one above it. When the flag falls a large quantity of gas comes off; but if I bore anywhere along the levels I could get gas, and light it, and it would burn for weeks. Therefore, if there happens to be a slight crevice in the roof, no ventilation could provide against that; and when such is the case, nothing but safety-lamps can be used with safety. As to the single shafts, I remember a case in South Staffordshire, seven years ago, where instead of sinking two shafts, they sank a small one, called a trumpet, by the side of the other. The stables took fire at the bottom of the shaft, and, instead of the air going down the drawing pit and up this trumpet, the air was reversed by the flames, and the flame came out at the top of the pit. The seven men who were in the pit were all lost, and the fire burnt so fiercely for 24

hours, that no one could go into the shaft at all. In my own opinion nothing is safe but two shafts. Through the burning or destruction of the brattice, or in some other way, accidents are almost sure to happen unless the shaft is duplicated. I believe there are but two brattice pits in my district, and they were introduced from Scotland.

The President—There are not many in this district, and some of the owners are anxious to do away with them. The Page Bank accident, (Durham,) where the brattice took fire, and shut up a large number of men, should have given the death-blow to brattice pits.

Some conversation then took place upon a suggestion to have the discussions at the meeting following the reading of the papers, but it did not meet with the concurrence of the meeting.

Mr. George Charlton said that single shafts had been sunk in the north of England because of the great expense of sinking; but if the coal would not pay for the sinking of two shafts, it ought to remain in the ground until it was of sufficient value to do so. He believed Mr. Dunn was doing all he could to get double shafts; but though the inspectors were armed with powers to recommend, they could not make laws. He thought Mr. Goodwin was perfectly right when he said that outbursts of gas were reported when it would have been more correct to say there had been a suspension of ventilation.

Mr. Goodwin—If my remarks were correctly understood at the last meeting, it was a question of doubt in my mind whether there were sudden emanations of gas such as not to be overcome by 20,000 cubic feet of air per minute, or whether they could be called outbursts when they come below that point. I have never disputed that emanations of gas take place. I am very pleased with the

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 11.] [Session 1861-62.

ORDINARY MEETING, *Tuesday, February 25th*, 1862.

JOSEPH DICKINSON, ESQ., F.G.S., President, in the Chair.

Mr. E. W. Binney asked the opinion of the meeting upon the propriety of forming a local fund for the relief of widows and orphans and other persons dependent upon men killed or disabled in following their occupations as coal miners. He said if a district association were formed in Lancashire and Cheshire, instead of a central association in London, as was proposed, it would probably commend itself more to the coal owners and the public here than the one in London, and the funds would probably be better dealt with, and the colliers would have more faith in it. Probably the best way to proceed would be to call a public meeting of the coal proprietors, and Manchester was a place where such a thing might be well started.

The President said he understood that there was already a surplus from the Hartley Colliery Fund, which was to be applied as the nucleus of a fund for the Northumberland and Durham miners, who had expressed their preference for a local fund

rather than a national one. There was ample scope for a local fund for Lancashire and Cheshire, and the Manchester Geological Society was a very proper medium by which to bring it before the public, because it stood on neutral ground.

Mr. Andrew Knowles thought that if the fund was confined to Lancashire and Cheshire the money would be more equitably distributed than by a London association. Mr. Binney had not explained the manner in which the fund, when collected, should be distributed.

The President said the fund would no doubt be for the widows and others dependent on those who might lose their lives.

Mr. Binney said the manner of distribution would be a proper subject for discussion at a meeting to be called to consider how the subscriptions could be raised. No doubt the coal proprietors and the colliers themselves would contribute, and it was a question whether a sick club might not be connected with the fund; but all those are things to be decided hereafter.

The President—Sick clubs seem to be already well managed by the people who have started them.

Mr. John Fletcher—Are you not magnifying the necessity for a call of this kind upon the public. I think I am right in saying that whenever an accident has happened there have been sufficient funds provided in the neighbourhood. The recent Hartley case of course has become a national affair; but I do not think we should infer from it that it has become necessary that the whole nation should be called upon to meet accidents of this kind. I think there is a disposition on the part of colliery owners to assist liberally; and as long as the accidents are diffused over the country, they are met in the ordinary way.

The President—It is generally found that in small accidents, where only one or two persons are killed, the relatives are not provided for so well as in more extensive cases.

Mr. Fletcher —Of course they are not provided for so well as the relatives in the case of the Hartley colliery. It has been suggested as desirable to form a fund, to be provided by the workmen and masters. I am not at liberty to say all I know on the subject, but it is a matter that is being now mooted, and may probably be the subject of legislative enactment.

The President suggested the propriety of adopting some resolution upon the subject.

Mr. Lacey agreed that the most natural way of forming a fund seemed to be by weekly contributions generally, both by men and masters, over the whole district.

Mr. Fletcher suggested that the subject might be adjourned till after the proposed discussion by the mining association in London.

Mr. Binney—The only question is whether a fund of this sort would not be better managed on the spot—whether the men would not have greater faith and confidence in it. If the money which they contributed was sent to London, and London men were to come down to investigate every case, it would seem a roundabout sort of way of doing it.

Mr. Fletcher—The distribution of the money is an important question; the first thing, however, is how to raise it.

Mr. Binney—It has been proposed to charge ½d. or 1d. per ton upon the coal.

The President—The question is a very proper one for discussion; but a special meeting should be called to discuss it.

Mr. Atkinson (honorary secretary)—A charge of ½d. per ton upon the sixty millions of tons raised annually would amount to £125,000 a-year, and that would be a very large fund. Would it not be desirable to call a public meeting of miners and geologists on the subject? I will propose, "That a meeting be held at some convenient and not distant day for the discussion and investigation of this subject."

Mr. Fletcher—Seeing that this matter is to be brought forward in London before our next meeting, I think it would be better to leave it over till then.

The President—Then I will take that as the pleasure of the meeting.

Mr. John Plant—I beg to exhibit a specimen which I received from Runcorn, You will perceive it comes from the red sandstone there. It was shewn to me as the jaw-bone of a fish, but as I hardly agree with the person who brought it to me, I should like to submit it to the members of this Society.

Mr. Atkinson—I should not think it is the jaw of a fish, but the pith of some plant broken up into sections.

Mr. Binney—It would be a strange sort of a jaw with the teeth so disposed. It is very likely to be a sternbergia. A diaphragm had no doubt divided one small portion of the pith of the plant from another, and thus given the appearance of teeth.

Some conversation followed, in which the speakers concurred with Mr. Binney.

Mr. Binney then read a short paper by Mr. J. J. Landale, Mining Engineer, Edinburgh—

On Mr. Aytoun's Patent Safety-Cage for Mines.

The description given in this paper was illustrated by large coloured drawings; and as it would not be understood without graphic illustrations of a more elaborate kind than we usually give, we are obliged to omit it, and to rest satisfied by saying that the principle of Mr. Aytoun's Safety-Cage appears to differ from that employed in those in ordinary use, in this, viz.:—that it provides for the safety-apparatus being quickly brought into action, by the intervention of two strong springs, before the cage shall have acquired a dangerous velocity; whereas those in previous use, we believe, have no provision for hastening the action of the safety-apparatus, except the weight of the cage and its contents. The author of the paper seemed to consider that all the safety-cages previously brought before the public had been complete failures; but he thinks the fate of the one he described will be different, as the principle upon which it is constructed will render the miner in his descent to and his ascent from his daily labour nearer *complete safety* than he has hitherto been.

On the motion of Mr. A. Knowles, seconded by Mr. Barr, the thanks of the meeting were voted to Mr. Landale for his paper.

The President—It is perhaps going too far to say that all these safety-cages which have already been tried have proved failures.

We have Owen's Safety Apparatus in this county, which is working well, and it appears to me to be giving great satisfaction. I think the remarks of Mr. Landale, in this respect, must be taken as applying to those they have had in Scotland, not to those in this part of the country.

The chair having been taken by Mr. Binney,

The President, in the absence of its author, read the following paper, by John J. Atkinson, Esq., her Majesty's Inspector of Mines for the South Durham district:—

On the Gases met with in Coal Mines, and the general Principles of Ventilation.

The following remarks were written in the hope that some or other of them might prove of service, in conveying to the merely practical miner, a general knowledge of the laws and principles of ventilation, as applied to mines; and of the nature and properties, chemical and physical, of our atmosphere; as well as of those of some of the gases most frequently encountered in coal mines. They were not intended to have been communicated to either this or any similar institution, or they would, in all probability, not only have been put into somewhat different language, but would also have placed some of the matters to which they refer in a more purely scientific point of view. But, after all, such an alteration would perhaps have rendered them less useful than it is hoped they may prove to the particular class of persons for whom they were written, such as underviewers, overmen, deputy overmen, and even workmen who may wish to fit themselves for assuming any of these offices; and, at the request of my colleague, your present President, I venture to submit them to your notice.

A variety of different kinds of gases are given off by the coal and other minerals met with in coal mines. A further supply of gases arises from the breathing of men and animals, and from the burning of candles and lamps, as well as from the explosion of the powder used for blasting the coal and stone in the mines. The whole of these gases are capable of causing the death of men and animals breathing them in their pure and undiluted state. And some of them require to be mixed with many times their own volume of air, before the mixture they form with it, can be breathed, for any great length of time, with safety.

Some of the gases given off in coal mines, when mixed with certain proportions of air, form violently explosive mixtures. Such a mixture of air and gas, on being ignited by a naked candle or other flame, suddenly explodes, and becomes one mass of living flame, scorching and burning everything that may happen to be in contact with it. Such an explosion, in general, also creates a complete hurricane, or tornado, of immense force and violence, tearing and driving all before it—knocking down the masonry erected for the guidance of the ventilation, as well as the props and timber erected to support the roof of the mine, which falls in great masses, causing bodily injury or death to those it may fall upon, and often enclosing and imprisoning those who, being unhurt by its fall, are left stunned by the concussion, more or less scorched by the flames, and without lights, shut up to breathe the deleterious atmosphere produced by the explosion. The flames of such an explosion being extinguished, and its violence exhausted, there remains an atmosphere so hot, and so charged with noxious gases and steam, as to cause the death of all who are left alive to inhale or breathe it. This resulting atmosphere is generally termed *after-damp*.

The grand object of the ventilation of mines is to cause such a current of air constantly to circulate through them, as shall, by

mixing with and diluting the gases, render them harmless, and, in that state, carry them off as quickly as they are produced in the mines. It is here proposed, in the first instance, to remark upon the chemical composition of the air we breathe; then upon those of a few of the most important gases met with in coal mines; and afterwards to notice some of the leading principles of ventilation, by taking advantage of which we get rid of the gases as fast as they are given off in mines.

Atmospheric Air.

Air is, almost entirely, a mixture of two gases, oxygen and nitrogen; carbonic acid is also present in limited but variable proportions, forming on an average about 1 part to 2,500 parts of our atmosphere. Besides *oxygen*, *nitrogen*, and a trace of *carbonic acid gas*, in the atmosphere, there is always more or less of watery vapour diffused through the gases of which it is composed; but this vapour is variable in amount, is not considered as forming a constituent part of the atmosphere, and is therefore not embraced in statements as to the chemical composition of air; yet its effects are of the highest importance, both in the general economy of nature, and also in considerations relative to the ventilation of mines.—Dry air is chemically composed of—

	By Weight.	By Volume.
Nitrogen Gas.....	77 per cent.	..... 79 per cent.
Oxygen Gas	23 ,,	..... 21 ,,
	100	100

A cubic foot of air at the temperature of melting ice (32°), and under a pressure of 14·7 lbs. per square inch, or 2116·8 lbs. per square foot, weighs 0·080728 lb.; so that under the same conditions 1,000 cubic feet weigh 80·728 lbs. avoirdupoise.

Nitrogen Gas.

Nitrogen gas is rather lighter than air, taken in equal volumes, at the same temperature, and under the same pressure. The

specific gravity of air being taken as 1,000, that of nitrogen gas is only 971·37, so that the weight of 1,000 cubic feet of air being 80·728 lbs., that of 1,000 cubic feet of nitrogen is only 78·411 lbs, at the temperature (32°) of melting ice, and under the pressure of the atmosphere, taken at 14·7 lbs. per square inch, or 2,116·8 lbs. per square foot. A cubic foot of nitrogen, under the same conditions of temperature and pressure, weighs 0·0784411 lb, and a cubic foot of air 0·080728 lb., as before stated.

Nitrogen gas has neither colour, taste, nor smell, and, so far, it is like air itself. It will not support life, but causes death when breathed. It will not support combustion, but extinguishes lights. This gas has very little chemical affinity or attraction for other bodies; its chemical properties are rather those of indifference than of activity. Its position amongst gases in general being almost like that of water amongst liquids, as it serves to render their properties less active. It dilutes the oxygen of the atmosphere, which could not long be breathed without being diluted with nitrogen. Nitrogen is, however, probably the best part of manures for land; and it is a component part of nitrous oxide or laughing gas, of ammonia, and of nitric acid, or aquafortis, as well as of many other compounds.

Oxygen Gas.

Oxygen gas, as has been stated, forms about 21 parts by volume, or 23 parts by weight, out of every 100 parts of air, being rather more than 1-5th part. The specific gravity of air being taken as 1,000, that of oxygen gas is 101,5·63; 1,000 cubic feet of air at 32°, and under a pressure of 14·7 lbs. per sq. inch, weigh 80·728 lbs.; 1,000 cubic feet of oxygen gas, under the same conditions, weigh 89·256 lbs.; so that this gas is rather heavier than an equal volume of air. Oxygen gas has neither colour, taste, nor smell. This gas, in a free and uncombined state, is essential to life; we must breathe it in this state, or die. But,

in its undiluted state, it is not fit to breathe beyond a very short time. In our atmosphere, it is fitted to sustain life by dilution or mixture with nitrogen gas. Chemical compounds in the gaseous form may contain large proportions of oxygen, and yet be unfit for respiration or breathing;—to be suited for this purpose the oxygen must be free and uncombined, and at the same time diluted.

Oxygen is the most abundant substance in nature, and constitutes at least one-third of the solid mass of the earth—23 per cent. of air, and 89 per cent. of water. Oxygen has strong affinities, and combines with all known substances, excepting *fluorine*. It forms, with other substances, no less than 136 inorganic compounds, and it would be difficult to say how many organic ones. This gas is the great supporter of combustion. Substances that burn in air, burn much more vividly in pure oxygen, shewing that the oxygen in the air is the supporter of combustion. Iron wire will burn in oxygen, but not in air; and this is also the case with other metals in a finely divided state. When, by breathing, we inhale air into our lungs, a part of the oxygen it contains combines with carbon, and we exhale or breathe out, as the result, an equal quantity, by volume, of carbonic acid gas, and, consequently, liberate about $3\frac{16}{21}$ times as great a volume of free nitrogen gas.

Having glanced at the chemical constitution of the atmosphere, let us next consider that of the principal gases met with in coal mining.

Carbonic Acid Gas.

When this gas is met with in coal mines it is often called *Stythe, Choke-Damp, or Black-Damp*. It is composed of oxygen and carbon. We have already considered the nature of oxygen, as a component part of the atmosphere; but we must not expect to find it show the same properties when chemically combined either with carbon or any other substance whatever.—Carbon, the

other part of choke-damp, forms the chief ingredient in coal; and coke contains a still larger proportion of this substance; but the diamond is pure carbon, in a crystalline state. The chemical composition of carbonic acid gas is—

	By Atoms.	By Weight.	By Volume.
Oxygen	2	73⅓ per cent.	1
Carbon	1	27⅔ „	1 *
	1	100	1 condensed.

Now, although this gas contains nearly 8 parts out of 4, by weight, of oxygen (the life-supporting element), yet, because it is combined with another substance (carbon), the result is, in this case, a poisonous gas. It is dangerous to life to breathe air containing 8 per cent., or 1-12th of this gas. Lights are extinguished in air containing 10 per cent., or 1-10th of it. At 32°, under a pressure of 14·7 lbs. per square inch, 1,000 cubic feet of air weigh 80·728 lbs., and 1,000 cubic feet of carbonic acid gas weigh 128·440 lbs., so that it is rather more than 1½ times as heavy as an equal volume of air. The specific gravity of air being 1,000, that of carbonic acid gas is 1,528·01. Before being mixed with air it rests next to the thill, or floor of mines, owing to its great heaviness or density when compared with air. This gas, besides being given off naturally, in many mines, is always found to result from the breathing of men and animals, the burning of candles and lamps, and, mixed with other gases, from the explosion of the powder used in blasting. Near the mouth of an adit, or drift, at Butterknowle Colliery, in the county of Durham, the writer has seen several small birds lying dead from the effects of this gas. They had come to feed upon crumbs where the workmen ate their meals, close to the mouth of this, an abandoned drift; and the gas coming out of the drift at the level of the ground, had overcome them. At the same colliery, in several places where the coal

* Bunsen assumes the hypothetical volume of carbon at one half of that assumed here; but as he gives its density at double the value here given to it, the results are not altered.

being lighter than air, it lodges next the top, or roof, in mines, until, by diffusion, it gets quite mixed with the air. This gas would soon cause death, if breathed in a pure and undiluted state; but, when mixed with twice its own volume of air, it may be breathed for some time without serious effects. It quickly extinguishes lamps or candles, when unmixed with air. Fire-damp, or light carburetted hydrogen, contains nearly 25 per cent., by weight, of hydrogen. Hydrogen is the lightest known gas, being only 1-14th part of the weight of air. The hydrogen in fire-damp is, however, condensed into a smaller volume than it occupies in a free state. Light carburetted hydrogen gas is chemically composed of—

	By Atoms.	By Weight.	By Volume.
Hydrogen	2	24·6 per cent.	2
Carbon	1	75·4 „	1
	1	100	1 condensed.

In the fire-damp of mines, however, we find a small proportion of other gases mixed with it. When 1 part of fire-damp is mixed with 30 parts of air, by volume, its presence can be detected by the appearance of the flame of a candle; and as the quantity of fire-damp is gradually increased from one up to two parts in 30 of the air, the appearance of the flame is more and more affected by it: but even in the latter proportion the mixture will not explode. The flame of the candle is surmounted by a pale blue halo, called in mining language a "top," or "cap," which partakes more or less of a brown colour, according to the quantity of *stythe* or carbonic acid gas that may be present, along with the fire-damp. The examination of the flame, for the purpose of forming a judgment as to the quantity of fire-damp mixed with the air, in mines, is, in mining dialect, called "*trying the candle*," or, "*trying the lamp.*" When the fire-damp forms as much as 1 part out of 13 of the air, the mixture becomes explosive, so that, if ignited by an exposed flame, the whole of the mixture is converted into a mass of flame; in this state of the mixture, however, the force of

the explosion is comparatively feeble. When there is only 9 to 10 times as much air as fire-damp, the explosive force is greatest. If the proportion of gas be greater than 1 part out of 9 to 10 of air, by volume, the force of explosion gradually becomes less and less, until there is only five times as much air as gas, when the mixture will no longer explode, but, on the contrary, extinguishes the flames of candles or lamps that may be brought into it.

The presence of carbonic acid gas, or of free nitrogen gas, in mixtures of fire-damp and air, is found to lessen their explosive force; so that if we add to the most explosive mixture 1-7th part of its volume of carbonic acid gas, it will not explode at all. Air containing one-fourth part of fire-damp, by volume, may be breathed for some time without very serious effects being produced on the animal frame. Common coal gas, as used for lighting, contains a large proportion of light carburetted hydrogen gas—the fire-damp of mines. Beside this, however, it contains a considerable proportion of pure hydrogen, some carbonic oxide, and some olefiant gas.

When a mixture of air and fire-damp is exploded, the chemical changes that take place, and the nature of the resulting mixture, or after-damp, is as follows:—

MIXTURE BEFORE EXPLOSION.

		By Atoms.					By Measure.		
		No. of Atoms.		Relative Volume p. Atom.		Uncombined Volume.	Combined Volume.	Volume per cent.
Air..	Oxygen	4	×	1	=	4	18·8	90·385
	Nitrogen	7·4	×	2	=	14·8		
Fire-Damp.	Carbon	1	×	2	=	2	2	9·615
	Hydrogen.....	2	×	2	=	4		
						24·8	20·8	100

MIXTURE AFTER EXPLOSION.

	By Atoms.				By Measure.		
	No. of Atoms.	Relative Volume p. Atom.			Uncombined Volume.	Combined Volume.	Volume per cent.
Free Nitrogen.....	7·4	×	2	=	14·8	14·8	71·2
Carbonic Acid Gas { Carbon	1	×	2	=	2	2	9·6
Carbonic Acid Gas { Oxygen	2	×	1	=	2		
Steam { Hydrogen..	2	×	2	=	4	4	19·2
Steam { Oxygen.....	2	×	1	=	2		
					24·8	20·8	100

Before explosion there may happen to be present, either an excess of air, or of fire-damp, beyond what is necessary to cause the explosion; and if so, they will remain mixed with the after-damp, in an unchanged state, after the explosion has taken place. There never can, however, be such an excess of air present, as to render the after-damp fit to breathe, or the explosion could not take place;—the limits are such that this is impossible. The above proportions of 1 of fire-damp to 9·4 of air, form the most explosive mixture; all other proportions forming less explosive mixtures.

From the second table, we perceive that the after-damp contains between seven and eight times as much free nitrogen as carbonic acid gas, or choke-damp. It was at one time, a popular mistake to suppose that the injurious part of after-damp consisted only of carbonic acid gas, or choke-damp;—not amongst scientific chemists, but amongst respectable mining authorities;—and that, not very long ago.

After-damp, it may be seen, by the second table, contains about 71 parts of free nitrogen, 9½ parts of carbonic acid gas, and, at the moment of explosion, 19 parts of steam; so that it may be said, at this stage, that after-damp contains, in round numbers, seven parts of nitrogen, one part of carbonic acid gas, and two parts of steam, out of a total of 10 parts. Directly after the explosion a large part of the steam condenses, and leaves, as a residuum, about

7½ parts of nitrogen, and one part of carbonic acid gas, out of eight parts; the whole unfit to breathe, and incapable of supporting either life or combustion. A small excess of air, or of fire-damp, might be left mixed with the after-damp of an explosion, beyond what is noticed in the tables as being chemically changed; but in no case could the air of the after-damp contain less than twice its own volume of deleterious gases, or the explosion could not have taken place;—such a mixture, if breathed, would soon cause death. Since explosions cannot always be prevented, how important it is, then, to be prepared to mix and dilute the after-damp with fresh air, in as speedy a manner as possible, after their occurrence. If there is more fire-damp present than is chemically changed by an explosion, the force of the explosion itself is lessened, but the after-damp resulting is more deadly than if an excess of air had been present at the time of explosion.

Carbonic Oxide.

This gas is sometimes called white-damp, when met with in mines. Assuming, as before, that the atomic volume of carbon is twice as great as that of oxygen, its composition is as follows:—

	By Atoms.	By Weight.	By Volume.
Oxygen	1	56·69	½
Carbon	1	43·31	1
	1	100	1 condensed.

Its specific gravity is 975·195, that of air being assumed at 1,000; so that 1,000 cubic feet of air at 32°, and under a pressure of 14·7 lbs. per square inch, weighing 80·728 lbs.; an equal volume of this gas under the same conditions will weigh 71·726 lbs. and one cubic foot under the same conditions will therefore have a weight of ·078726 lb.

Carbonic oxide has a much more deleterious effect on the animal economy than carbonic acid; air which contains only one per cent. of carbonic oxide, almost immediately causes the death of warm-blooded animals, as has been shown by the decisive experi-

ments of M. Felix Leblanc. Carbonic oxide is itself an inflammable gas, but does not support the combustion of other bodies. It has no taste, but has a peculiar odour. Small animals immersed in it die instantly. When inhaled it produces giddiness and fainting fits, even when mixed with a fourth of its bulk of air. It is easily kindled, and burns with a blue flame, being transformed into carbonic acid by the process. The carbonic acid formed by combustion at the bottom of a coal, coke, or charcoal fire is sometimes converted into carbonic oxide, by being deprived of a part of its oxygen, as it passes upwards through the red-hot embers; and, on coming into contact with the air, at the top of the fire, burns there, with a blue flame, and is again converted into carbonic acid gas. This gas is perhaps never found in coal-mines except as the result of the explosion of gunpowder, or the combustion of coal or wood. Carbonic oxide is obtainable in a state of purity by heating yellow ferrocyanide of potassium, with eight or ten times its weight of oil of vitriol. Bunsen obtained it by slightly heating a mixture of formic and sulphuric acids; and to ensure the perfect purity of the gas he passed it through a concentrated solution of caustic potash. Such a proportion of this gas might be mixed with air, as to form a mixture in which candles or lamps would burn, while life would become extinct; and it is probable that many deaths in mines have resulted from this gas, in situations where the lights have continued to burn.

It appears to be very probable that the deaths of the men and boys in the late accident at Hartley Colliery arose in a great measure from this gas, given off by the furnace after the stoppage of the air-current by the closing of the shaft; inasmuch as the lights used by the workmen engaged in clearing the shaft appeared to be rather increased in brilliancy than otherwise, at the time when the worst effects were felt from the escaping gas; and the mine gave off no fire-damp, and very little choke-damp.

At page 120, in the minutes of evidence taken before a Select Committee of the House of Commons, on accidents in mines, in 1835, the late George Stephenson, in reply to question 1853, gives an account of an accident at New Bottle Colliery, by which several persons lost their lives by a gas in which the lights burnt well, and which the witness supposed to have been sulphuretted hydrogen gas; but it appears to be more probable that it was a mixture of carbonic oxide, sulphurous acid, and a small quantity of carbonic acid gases, generated by the explosion of gunpowder in the drift, where it was found to prevail; because sulphuretted hydrogen gas has a particularly offensive smell, of which no mention is made in the account of the accident.

The writer is acquainted with several instances where gases have caused deaths, and with others where they have caused severe indisposition, in places where candles continued to burn brightly; in some of these cases, the gases were apparently produced by the explosion of gunpowder, and in others, by the combustion of coals; and hence it appears to be probable that carbonic oxide was a prominent ingredient in them. In an experiment by M. Leblanc, a large-sized dog was asphyxiated in an atmosphere which contained 4 per cent. of carbonic acid, and only ½ per cent. of carbonic oxide.

Hydro-sulphuric Acid, or Sulphuretted Hydrogen.

This gas is sometimes met with in coal-mines. It is colourless but distinguishable by its unpleasant smell, which resembles that of rotten eggs. It produces fainting fits and asphyxia, if inhaled, even when present only in very small proportions with atmospheric air. When inhaled, in its pure state, it acts as a powerful narcotic poison. It does not support combustion, but is itself inflammable, and burns when exposed to a supply of air and ignited; and when mixed with oxygen gas the mixture is explosive. It reddens tincture of litmus, but the reddening disappears on exposure to the air.

The composition of sulphuretted hydrogen is as follows :

	By Atoms.	By Weight.	By Volume.
Sulphur	1	94·15	1-6th
Hydrogen	1	5·85	1
	1	100	1

According to Bunsen the specific gravity of this gas is 1174·88 ; that of air being assumed at 1000, under the same conditions as to temperature and pressure.

Sulphuretted hydrogen gas may be inflamed by charcoal or iron, even at a low red heat. In air it burns with a blue flame, forming water and sulphurous acid, and depositing sulphur. According to some authorities 1-1500th part of this gas in air is instantly fatal to small birds, 1-1000th killed a middle-sized dog; and a horse died in an atmosphere that contained 1-250th part of its volume. The presence of sulphuretted hydrogen gas in the atmosphere, even in small proportions, can be detected by its action upon moist carbonate of lead, spread upon white paper, which it blackens. M. Parent Duchâtelet observed that workmen breathed with impunity in an atmosphere containing 1 per cent. of sulphuretted hydrogen, and he states that he himself respired air containing as much as 3 per cent. of the gas, without experiencing any serious results. This gas is formed whenever sulphur in a very comminuted form is brought into contact with hydrogen, in the act of being given off, and is probably formed, to some extent, where pyrites are undergoing decomposition in mines. When this gas is present with the air, in mines, candles will burn in the mixture, so that, if it is not detected by its odour, it may prove fatal to life before its presence is detected.

It appears to be probable that this gas is frequently formed in old unventilated workings partly filled with water. There are two instances mentioned by Mr. Nicholas Wood, in his evidence before

the Committee of the House of Commons on accidents in mines, in 1853—one at Hartley Colliery, which proved fatal to one person, and another at Tyne Main Colliery, where ill-effects were felt, notwithstanding that the lights burnt well, both of which, in all likelihood, were due to the generation of this gas from the action of the water upon pyrites in old workings.

A man breathes into his lungs about one-fifth of a cubic foot of air per minute, and converts about seven per cent. (by volume) of this into carbonic acid gas, which, with about three and three-quarter times as much free nitrogen, he exhales, along with about 66½ per cent. of the air he breathes, in an unchanged state. The largest lamp used in mining converts less oxygen into carbonic acid gas than a workman. Both give off watery vapour as well as carbonic acid gas. When coal is on fire it gives off, in burning, carbonic acid, carbonic oxide, and sulphurous acid gases. The explosion of gunpowder gives rise to carbonic acid, nitrogen, carbonic oxide, and steam; besides carburetted and sulphuretted hydrogen in small proportions. In the ordinary course of mining these causes give rise to so small a quantity of gas, in proportion to the air, that they hardly belong to the subject in hand; unless in reference to the state of a confined and unventilated part of a mine, where a shot has been fired; or in the more rare case, of coal being on fire in a mine.

Sir Humphrey Davy discovered that the flame of ignited gas would not pass through fine wire gauze, containing 28 holes for each inch in length, or 784 holes per square inch, unless the gas is moved with great velocity against the gauze, or the gauze against the gas; and by enclosing the flame of an oil lamp in a cage made of this gauze we are able to carry a light into an explosive mixture of air and gas without setting the gas on fire, on the outside of the gauze; by means of which an explosion is avoided. If we find ourselves with a safety-lamp in an explosive atmosphere,

we should only try to put out the flame by carefully drawing down the wick, and by no means try to blow it out, or we might blow the flame through the gauze, and cause an explosion. An explosion might result from drawing the flame of the lamp through the gauze by means of a tobacco pipe; yet workmen are not unfrequently detected in this very daring and dangerous practice in mines. Outside feeding, or oil-tubes, used to be attached to safety-lamps, but these are dangerous, as the flame might pass down the wick tube, and up the oil tube, and so fire the gas on the outside of the lamp, if the oil plug was out, or fitted badly, and the wick was small compared with the tube; but feeding tubes are not used now, at least in many districts. There are several sorts of safety-lamps now more or less used, which give more light than the Davy-lamp; glass being used in lieu of gauze opposite the flame. Glass is brittle, and liable to crack from unequal expansion, and many persons do not think glass lamps so safe as the Davy, in consequence. The late George Stephenson contrived a safety-lamp, having both glass and gauze around the flame, known as the Geordy, or Stephenson-lamp. The Davy-lamp is perhaps the best known lamp for detecting the presence of a small mixture of fire-damp in the air of a mine.

Now since fire-damp, choke-damp, and other gases are met with, in more or less abundance, in all coal mines, it becomes an important question as to how the bad and often fatal effects they are likely to produce, if not properly dealt with, may best be avoided. To this end it has sometimes been proposed to get them to combine chemically with some substance to be presented to them as they are given off; and only a short time ago a Mr. Wall had a proposition of this kind before the public. So far, however, the best mode of dealing with them appears to be to dilute them with very large quantities of fresh air, and to sweep them out of the mine by an energetic ventilation, as fast as they are given off or generated. After all, however, the natural laws

and principles, operating in the production of ventilation in mines, have been less generally studied in England than on the continent; and from this cause many mistakes have been made in the practice of ventilation in this country. New arrangements for the ventilation of mines have sometimes been made at great cost, and have not been found to answer when completed. In a few cases, lives have been lost from this cause; in others, an inferior arrangement and ventilation have been produced, where, by the application of these natural principles, a superior one might have been obtained at the same or even at a smaller cost. Many, if not all the members of this Society are familiar with the details of the general practice of ventilation as pursued in this country. Instead, therefore, of considering this part of the subject, it is here proposed rather to direct attention to the natural laws and principles affecting the ventilation of mines.

Natural Laws and Principles Affecting the Ventilation of Mines.

As an introduction to the general laws and principles affecting the ventilation of mines, let us notice some of the general physical properties of air and gases.—The world on the surface of which we live is a large globe, about 8,000 miles in diameter, and 25,000 miles in circumference. This great globe is surrounded by, and enclosed in, an atmosphere of air many miles in depth; so that the surface of the earth, where we live, is the bottom of a deep sea, or ocean of air. Air is composed of the two gases, oxygen and nitrogen, in the proportions that have been named. Air and all gases have the following physical properties:—They are *impenetrable*. If any space be filled with air, no two material bodies can occupy the same space, without first displacing the air, because no two material bodies can be in the same place at the same time. Two gases, or a gas and a vapour, may fill the same space (in a certain sense), by being mixed with each other, in the same manner that a sponge will hold water, but each gas or vapour must leave spaces vacant

for the other to occupy or fill. Air and gases are possessed of the property called *inertia*. With respect to motion and rest, air, gases, and indeed all kinds of matter, are said to be *inert*, so that they will remain either at rest or in the same state of motion, until acted upon by some force or resistance. This property merely implies what may be termed a negative quality, of such a character as to have the effect of causing matter not to change its state, whether of motion or of rest, without some force or resistance being applied to it to cause it to do so. Owing to the property of *inertia*, a body will remain either at rest or in the same state of motion, both as to speed and direction, in spite of any forces or pressures that may be acting upon it, provided they are equal and opposite forces, so as to counterbalance each other. This is the state of the atmosphere in a calm: there is always a pressure in every direction, up, down, sideways, diagonally, and in fact in every direction, in the air of the atmosphere. This pressure arises from the mere weight of the superincumbent air, and amounts, generally, to nearly one ton on each square foot, or 14 lbs. and upwards per square inch. If the pressure is lessened on one side, the ordinary pressure upon the opposite side drives the air towards the side where the pressure is reduced, and gives rise to a wind. If the pressure is increased on any side, the air is driven away to the opposite side, against the ordinary pressure. Air in motion cannot properly be said to have any more pressure or tension than the still air through which it moves. What would otherwise be extra pressure is really converted into motion in the air. Any excess of pressure really existing is simply that due to the friction which the air encounters in moving. This is a fact not always understood, and not always acknowledged, even in works pretending to treat the subject upon scientific principles. Force may be converted into mere motion without at all increasing the tension or spring of the air to which it is applied; if it does increase the pressure on the air, it is only to the extent of the resistance encountered. Air in motion is called "wind;" and owing to its *inertia* it will

only lessen its speed by meeting with frictional resistances, or by giving out its force to obstructions, such as the surface of the earth, houses, trees, wind-mills, and other objects; and in every case where power is taken out of the wind, it is done at the expense of lessening its velocity. If, for instance, we should make the wind passing through a mine drive a mill, we would thereby lessen the force and quantity of wind circulating in the mine, in a given time, if the pressure causing ventilation remained constant. Railway trains, at high speed, even in a calm, meet with a large share of their resistance from the air—the trains lose force, and the air gains what they lose. Owing to the *inertia* of the air, birds meet with such a resisting medium in it as to give them a fulcrum, or resting place for their wings, and enable them to fly. This property of *inertia* belongs alike to all material bodies, and may, in general terms, be called an *unwillingness to move, when at rest, or to change their speed or direction of motion when they are moving*, without a force or resistance being applied to cause them to do so.—Air is *compressible*. Air is squeezed and contracted into less and less bulk as we increase the pressure upon it. If we double the pressure (without changing the temperature), the same air only fills one half of the space; if we treble the pressure, it only fills one-third of the space; and if we apply four times the pressure, it only fills one-fourth of the space, and so on, provided that the heat or temperature of the air remains the same. This is called the law of Mariotte, or Boyle. The air at the surface of the earth is generally pressed by the whole of the air above it, at the rate of 29·922 inches of mercury (reckoned at the density due to melting ice, 32°), as shewn by our common barometers; a pressure equal to 2,116·4 lbs. per square foot. To give this pressure we should require the air of the atmosphere to be 26,216 feet high, if it was all as heavy as the air at the earth's surface. The fact is, however, that the air, as we go up, is pressed by less and less air above it; and owing to its elasticity, or spring, becomes lighter and lighter, so that instead of 26,216 feet, or nearly five

miles high, the atmosphere is immensely higher. It gets so much thinner, rarer, or lighter, that at—

3½	miles above the surface of the earth it is		2	times rarer.
7	,,	,,	4	,,
14	,,	,,	16	,,
21	,,	,,	64	,,
28	,,	,,	256	,,
35	,,	,,	1,024	,,

And so on. If we carry a barometer up a hill, we have less and less air above us, and its pressure will therefore support less and less height of column of mercury, and hence the barometer falls. If we take it down into a mine we get a longer column of air above us, and it supports a longer column of mercury, so that the barometer rises. In ordinary states of the weather mercury is about 10,800 times as heavy as the same volume of air near the surface of the earth, and hence about 900 feet, or 150 fathoms, of ascent or descent, make a change of one inch of mercury in the height of the barometer. This fact has been applied to measure the height of mountains by means of barometers, and it has sometimes been employed to estimate the friction of air in shafts. The difference between the height of the barometer at the top and the bottom of a pit 150 fathoms, or 300 yards in depth, is about one inch of mercury.

Air is *elastic*; it is a perfect spring, so that whatever force compresses it, is an exact measure of the force it will spring out with, if we take away the compressing force. The air, at the surface of the earth, is pressed at about 14·7 lbs. per square inch, and if we take half this pressure off, it will swell out to twice its previous bulk; if we take away three-fourths of this pressure, and only leave one-fourth, the same air will swell out and fill four times the space it previously occupied, and so on. Whatever force or power is expended in compressing air into less bounds, will be given out as force or power by the same

air, in swelling out to its former volume, when we take away the pressure so applied.

Air has *weight*, like all other material bodies. The weight of a vessel filled with air is greater than its weight when the air is pumped out of the vessel. A tall column of air, one foot square, and of the full height of the atmosphere, weighs nearly one ton. Another column, of the same height, and one inch square, weighs rather more than fourteen pounds. The weight of the atmosphere enables it to support a column of water nearly 34 feet high, or one of mercury nearly thirty inches high; and this pressure acts equally in all directions—up, down, sideways, and in fact, in every direction. The body of a man of average size is pressed by nearly thirteen tons weight from this cause.

The direction, speed, and force of the wind, depend upon the amount of the *difference* of pressure that gives rise to it; and, in general, has little or no connection with the *gross amount* of the pressure acting in the direction of the wind; because a large share of that pressure is counter-balanced by an equal pressure, acting in the opposite direction.

In the open air the velocity of the wind is the same as the velocity that a body would acquire by falling from the top to the bottom of such a column of air, of equal density, as, by its weight, would produce the same pressure as that which gives rise to the wind. For instance, if the state of the air, as to the temperature and pressure, is such that there is a pressure of 2,000 lbs. (which is nearly a ton) on each square foot, in one direction; and only 1,999 lbs. per foot, or one pound per foot less, in the opposite direction, when thirteen cubic feet of air weigh one pound, then, the difference of pressure, giving rise to the wind, is equal to one pound per square foot; and a column of air, one foot in area and thirteen feet high, would weigh one pound. But a body falling through a height of thirteen feet, under the force of gravity, would acquire a velocity of 8·02 times the square root of 13, or 28·8 feet per second; and this is, therefore, the velocity of a wind in the open air, due to a *pressure*, or rather, to a *difference of pressure* of one pound per square

foot, when the total pressure of the atmosphere is nearly 2,000 lbs. per square foot, and thirteen cubic feet of air weigh one pound. If we wish to find the velocity of such a wind in the open air as is due to a known difference of pressure on each square foot, we have, first, to find how many cubic feet of the air is equal in weight to the difference of pressure on a square foot which gives rise to the wind; and eight times the square root of this number is equal to the velocity of the wind, in feet per second. In like manner, if we would find the pressure giving rise to a wind, when we know its velocity, we must square the velocity, in feet per second, and divide the result by sixty-four and one third, and the quotient will be the height in feet of an air column giving rise to the wind; this height being divided by the number of cubic feet of air, weighing one pound, will give the difference of pressure in pounds per square foot, giving rise to the velocity. This rule is merely the reverse of the former one. A difference of pressure of only one pound to the square foot, under the conditions before stated, gives rise to a wind in the open air, having a velocity of 28·8 feet per second, or more than nineteen miles per hour, which is nearly equal to the highest velocity of the air in the upcast shafts of coal mines.

In practice, in the ventilation of mines, it is found to be necessary to employ a very much higher pressure than one pound to the square foot, in order to give rise to this velocity; it is, indeed, in many instances, necessary to employ from ten to twenty pounds per square foot to do so, and this pressure is equal to the weight of an air column 130 to 260 feet high, instead of only thirteen feet high as in the open air. It has been a very common mistake to consider that this difference shews a discrepancy between theory and practice; it shews no such thing. The true theory of any subject embraces in its grasp all the causes that operate, and can never fail to agree with practice—if it is really the true and complete theory. Theory, indeed, is a collection of general principles, gleaned or generalized from observation of the result of practical trials or experiments; and it is either a false or an incomplete theory, that does not embrace the whole of the general principles involved in any phenomenon we may observe. It would be true, and

therefore much more becoming, in such cases, to say that we do not understand the true theory, because the hypothesis or supposition we have adopted, does not agree with what we notice to occur in practice; and this ought to set us to work to try to find out what is the true theory of the matter; because practice, when not guided by general principles, is mere guess work or empericism, so far as regards every case excepting only that in which the observation itself is made.

The reason of from ten to twenty times the amount of force or pressure that is required to generate any velocity, in the open atmosphere, often being required to give rise to the same velocity in the air in mines, arises from the friction that air meets with, by rubbing against the sides of the air-ways, in passing through mines. Every square foot of surface exposed to the air travelling along the galleries of a mine, is pressed by the air, to the extent of about a ton of force or pressure, and it is, therefore, no wonder that extra pressure is required to overcome the friction arising from this immense pressure. If, for instance, we find that the last or final velocity of air escaping from a mine, by an upcast shaft, is such as to require a pressure of one pound per foot, or thirteen feet of air column to give rise to it, on the supposition that there were no friction; and if, at the same time, we find that the actual pressure employed is ten times as much, or ten pounds per square foot, we learn from this, that nine pounds out of the ten pounds per foot, are required to overcome the friction of the air in rubbing against the sides of the air-ways; the other one pound per foot, or one-tenth of the whole pressure only being required to give rise to the velocity. And this is no uncommon case in the practice of the ventilation of coal mines. Friction, then, arising from the air rubbing against the top, bottom, and sides of the air ways in mines, is really the greatest obstacle to be overcome by the ventilating pressure or power. The force required to put the air into motion, apart from friction, being very small in comparison, at least in a large majority of cases; particularly in coal mines, which generally require a much more energetic ventilation than is necessary for the salubrity of metallic mines.

To show the comparative amounts of pressure expended upon creating velocity in the air, and upon overcoming the frictional resistance it meets with in mines, respectively, the following cases are cited:

	Pressure in Air Column due to Velocity.	Pressure in Air Column due to Friction.	Total Pressure Employed.	Proportion due to Velocity and Friction, respectively.
	Feet.	Feet.	Feet.	
Hetton Colliery, 1st case	10·43	179·88	190·31	1-18th.
Do. Do. 2nd case	12·37	212·63	225·00	1-18th.
Haswell Colliery	13·84	140·66	154·50	1-11th.
Tyne Main Do.	25·70	177·50	203·20	1-8th.

The pressures due to velocities being those due to the final velocities at the tops of the upcast shafts.

From this it will be seen, that out of a total pressure of eighteen, at Hetton Colliery, no less than seventeen were employed on friction, and only one upon the velocity of the air.

At Haswell Colliery, ten parts out of eleven of the ventilating pressure, were spent upon the friction of the air; and only one part out of eleven upon creating its final velocity at the top of the upcast shaft.

At Tyne Main Colliery, seven parts out of eight of the ventilating pressure were spent upon friction; and only one part in eight upon the velocity of the air at the top of the upcast shaft.

From these examples it will be perceived, that the amount of ventilation in mines, and therefore, the safety, health, and comfort of the workmen employed in them, depend almost entirely upon the amount of friction that the air meets with under any mode of ventilation we may employ; and hence, the great importance of understanding the general laws and principles upon which the friction of air in mines depend; so that we may know how to reduce such friction to its lowest possible amount, and by this means obtain the greatest quantity of air, from any ventilating power we may employ.

Mr. John Atkinson, (Hon. Sec.) proposed a vote of thanks to Mr. Atkinson for his paper, and to the President for reading it. He remarked that the paper gave, in a very clear and explicit manner, the principles of Natural Philosophy, upon which ventilation depends.—Mr. Joseph Goodwin seconded the resolution which was unanimously passed.

Mr. Binney—I am sure we are very much indebted to Mr. Atkinson for giving us such a valuable paper.

Mr. Lacey inquired whether any of the members had tried a mouth-pad, formed of a mixture of quicklime and crystallized sulphate of soda; as recommended in a newspaper which he held in his hand, for the purpose of preventing the poisonous effects of carbonic acid gas in mines.

The President said he had explored a mine, with others, with mouth-pads, but ultimately they gave them up; they did not know that they derived much benefit from them, and it was found better to take the fresh air forward.

Mr. Binney remarked that the mouth-pad named was worthy of attention, and also that of Dr. Stenhouse, F.R.S., filled with charcoal, especially in taking dead bodies out of mines. There were a great many parts of the paper that might be profitably discussed.

The President said this was only the first part of Mr. Atkinson's paper; the second part, which was perhaps the more interesting to the colliery managers, was on the subject of the friction of air in mines. It would go into the subject and give rules for making the different calculations as to the pressures and powers required. He hoped they would be favoured with the attendance of all who were there to day, to hear the next part of the paper, at the next meeting.

Mr. Goodwin—For my own part I am glad to see such a paper brought before this meeting, more especially because, though a scientific subject, it has a practical bearing. All who have taken particular notice of the paper, will see that the main principles urged, are effective ventilation, and removing the obstructions in the shape of cramped air-courses. The object is to show the necessity of allowing as much air to pass through the mine as possible. I am quite aware that there is a limit to the size of all air-courses, and it is a fact to be regretted that, at all times, the limit is not adhered to, and they are often much below it. Another part of the paper to which I would allude, is in regard to the opinion so very often expressed, that carburetted hydrogen, or fire-damp, has not been injurious to health. On the authority of the writer of the paper, it is injurious, and that is therefore an additional reason why we should get rid of it. He holds the same views as I do upon this subject, that the gas can be removed as fast as generated; and this affords me great gratification as I have previously brought my views before the meeting. It is very possible that there are one or two points in the paper which have escaped my notice; but there is one other, namely, that light carburetted hydrogen gas exploded with greatest force when mixed in proportions, varying from 1 to 9 or 1 to 10. Upon this subject I purpose giving my views to the society at an early period.

The President—There is perhaps no higher authority on the the subject of mine ventilation than my colleague Mr. Atkinson.

Mr. Goodwin—I am sure of that.

The President—He states that the gas puts the lamp out when in the proportions of 5 to 1.

Mr. Goodwin—I want to know whether the mixture of gas that comes below this point is dangerous, or how it is to be detected. Is

it possible to deal with it, when below the point named? to understand that the greatest force of explosion is the mixture named, for we always find that the higher lamp, the clearer the gas fires.

Mr. Binney—I think Sir Humphrey Davy gives a different from that of Brande. Anyone may make these e for himself. I have seen gas fired when it was said "sharp." About 1 in 8 gives the maximum force of exp

The President—In answer to the question whether t means of testing this gas when it exists in proportio that it extinguishes the light, I think we find generall the line of division where the fire-damp begins, and wh is not so fine but that there is a margin, on entering can test its presence by the ordinary top of the flame, a the lamp a little further you get into the more den Such has been the result of my observation. I have n the mixture so strong but that I could tell whether damp or not by the appearance at the entrance of it. V to the gases produced by the ignition of fire-damp, on a mine to rescue men after an explosion, one can almos go much further by keeping close to the floor, und after-damp, than by keeping the head near the top of t or roof. This arises no doubt from the after-damp be and from the large amount of free nitrogen—a lighte air—contained in the products of the exploded gases, as in the paper.

Mr. Goodwin—I think my remarks have been misu What I wished to say was, that the gas, when in its l takes its highest position; and wherever we find fire find it keenest at the roof. According to the theory laid upper stratum should contain a gas too pure for expl such is not the case in practice.

Mr. Binney—We generally find in practice that near the roof, in a dead place, there the fire-damp will get; there may be plenty of places in the lower part of the mine quite clear, but at the roof an explosive atmosphere may exist. By the law of the diffusion of gases, if you give sufficient time, they will permeate amongst one another; but it is pretty well known that fire-damp will get into high places. This is a very valuable paper; all I am afraid of is that it may be a little too scientific for the generality of overmen, firemen, and others; but it is difficult to make it more simple.

Mr. G. Charlton—I believe that as a rule the gases are found not so fully diffused in coal-mines as in the laboratory. After a slight explosion has taken place at the entrance of a mine, we do not discover diffusion to take place very rapidly, so that the free nitrogen may exist in that state a considerable time. I think that even a small quantity of fire-damp can be detected; and if the first warning of the presence of gas was noticed, and sufficient ventilation used to remove it, I apprehend that explosions would be reduced to a very small minimum indeed. With regard to the character of the paper just read, I think it is of the best possible order. It condenses and places in a lucid and clear form all the recent discoveries of chemists up to the present day, and it is made as clear as these subjects can well be made for even the underlookers and overmen to understand. With respect to the friction of air in mines, I believe that is one of the greatest points we have to attend to; because in exact proportion as we reduce the friction, the ventilation is increased. Wherever the air passages are so small as to produce a humming sound, it is a clear indication that too much friction, and its consequent obstruction of the current of air, exists there. In travelling the air-courses, whenever the drum of the ear is affected, it is a clear evidence that there is a great deal of friction at that point. The best course then to adopt, is to make the air-courses larger. If this is done, my opinion is, that with a proper use of the safety-lamp, and by

due attention to ventilation and the first indications of gas, no explosion need to occur in a colliery. I entirely approve of the paper given us by Mr. Atkinson.

Mr. Binney—No one can object to what Mr. Charlton has said. When gas makes its appearance the first thing to do is to get rid of it as fast you can. The only question is whether safety-lamps are not useful in addition, to be ready when ventilation gets out of order.

Mr. G. Charlton—In our deep colliery, we make it a point to have no open lights beyond the shaft level, and from that circumstance it arises, that from the opening of the pit to the present moment there has not been a particle of gas exploded.

Mr. Binney—Miners say that gas is sometimes "sharp," but chemists have never explained what "sharp" gas is.

Mr. Farrimond—The dry state of the atmosphere affects gas. I find that in our deep mines it is more "sharp" when the barometer stands high.

Mr. Binney—The fire-damp in the Arley mine at Wigan is "sharp" gas.

Mr. Goodwin—There is a difference when the morning is frosty, and when it is warm.

Mr. G. Charlton—Besides the proportion of the gas, the pressure of the atmosphere acting upon the gas and compressing it up to a high state of tension, causes it to explode more powerfully, just as a large amount of oxygen causes the combustion to be more rapid and intense.

Mr. Binney—It goes off sharply without the least warning.

Mr. G. Charlton—The blue colour of the flame is the warning we have.

Mr. John Atkinson, (Hon. Sec.)—The force of the explosion probably varies with the temperature and consequent density. Gas will be denser on a frosty morning.

Mr. Binney—That is why a fire burns brighter in a frost.

Mr. A. Knowles—I know a case where there was pure fire-damp, and when the outer edge was lighted the remainder would not go off. It merely burnt at the outer surface.

Mr. Binney—Then there would not be oxygen sufficient for the combustion.

Mr. J. Atkinson, (Hon Sec.)—The fire-damp behaved in this instance like pure hydrogen, in the well known experiment where a light is applied to a vessel containing this gas. The light is extinguished, hydrogen not being a supporter of combustion, but the gas takes fire and burns away at its surface, by obtaining the requisite amount of oxygen from the air with which it is in contact. No doubt pure fire-damp or light carburetted hydrogen, undiluted by the quantity of air that renders it explosive, will act in much the same way.

Mr. G. Charlton—If a perforation be made in a gas meter and a light applied, the flame of the gas will burn outside, but the gas inside will not be ignited, because it will not burn or explode without a supply of oxygen. On the outside, the oxygen necessary to support combustion is supplied by the air.

Mr. Binney—In some cases I have seen gas lighted in a coal-mine, and a flame travel to a great distance, apparently following the lower edge of the light carburetted hydrogen, where it is in contact with the air that exists below it.

Mr. A. Knowles—When large explosions have taken place, it has generally been because, behind the gas, there has been a current of air to supply oxygen to cause the light carburetted hydrogen to burn.

Mr. Binney—It is generally in coal-mines, usually well ventilated, but in which the ventilation has suffered some stoppage, that the most terrible explosions take place.

Mr. Jacob Higson spoke at some length on the inflammability of a gas which was emitted from a mine in Wales, of which he had the charge. The presence of which he had on many occasions been enabled to detect in the lamp, before an explosion had therein taken place; but he had not had an opportunity of experimenting upon it, with a view of ascertaining its composition. There were only two levels in the colliery where gas of so combustible a nature had been met with (though the underground workings were very extensive), and by always keeping the brattice within a few feet of the face thereof, round which a strong current of air was passing, little difficulty was experienced in removing so great a source of danger.

Mr. Binney—Do you feel any difficulty in breathing it?

Mr. Jacob Higson—No; but the nostrils and eyes are sensibly affected by its presence.

Mr. Binney—Carbonic acid will affect the eyes as much as carburetted hydrogen.

After some further conversation the meeting terminated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 12.] [Session 1861-62.

ORDINARY MEETING, *Tuesday, March 25th*, 1862.

JOSEPH DICKINSON, ESQ., F.G.S., President, in the Chair.

The President—I may inform you, gentlemen, that this Society has had a selection of the fossils and minerals of the late William Peace, Esq., F.G.S., Wigan, kindly offered by his sons, Messrs. Maskell Wm. and Charles O. Peace. The Council are of opinion that the offer should be accepted with thanks. Mr. Peace was one of the oldest and most useful members of this Society, and had an excellent collection of fossils and minerals; so that the offer is of great value to us. Mr. Binney, who I am sorry to find is absent to-day, has been over to see them, and says there are some very excellent specimens amongst them.

Mr. Peter Higson—I am sure the collection is a very nice one, and the present a very handsome one.

Mr. Thomas Knowles, (of the Ince Hall Collieries)—I think the Society is much indebted to the Messrs. Peace, and I shall have very great pleasure in proposing a vote of thanks to them for their hand-

some donation.—Mr. Peter Higson seconded the vote, which was passed unanimously.

The President—If no gentleman has any subject to bring before us, we will go on with the reading of Mr. J. J. Atkinson's paper; which, as you are aware, is a continuation of the paper read at the last meeting. Mr. Atkinson, I am glad to tell you, is present amongst us to-day; and he will be happy to give any explanation upon this paper or upon the one read at the last meeting, but he does not wish to be encumbered with the reading of it, and has asked me to undertake that duty for him.

The chair having been taken by Mr. Peter Higson, the President read the following paper, by John J. Atkinson, Esq., Her Majesty's Inspector of Mines for the South Durham district.

On the Friction of Air in Mines.

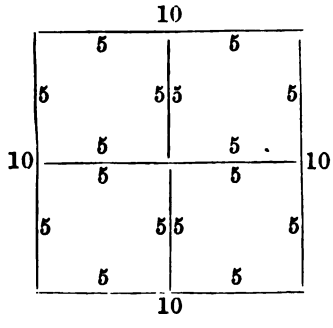
The amount of friction is reckoned or estimated by the amount of the pressure or force required to overcome it. Numerous experiments have been made to find out the laws that govern the friction of air and gases—both in pipes having an uniform section, and, to a less extent, in the irregular air-ways of mines. By these experiments, the following laws have been found to hold good in practice.

The pressure required to overcome the friction of air, increases and decreases, in exactly the same proportion that the area or extent of the rubbing surface, exposed to the air, increases or decreases; so that when the velocity of the air, and the sectional area of the air-way, remain the same, the pressure required to overcome the friction, is proportional to the area or extent of the rubbing surface exposed to it; and hence, if we double or treble the

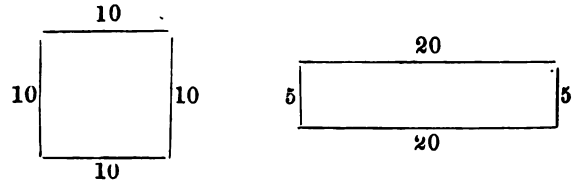
extent of the rubbing surface, we also double or treble the friction, or, what is the same, the force or pressure required to overcome it. The rubbing surface, of course, depends upon the circumference or perimeter of the air-way, and upon its length; the rubbing surface is found by multiplying the perimeter by the length of the air-way, where it has an uniform section. A circular pipe or air-way offers less rubbing surface, for the same length, than any other form or shape of air-way of equal sectional area; because the circumference of a circle is less, in proportion to its area, than the perimeter of any other figure, is to its area. A circle whose area is 1 has a circumference of 3·545, or rather more than 3¼;—the perimeter of a square is 4, when its area is 1; so that about 7 yards of square pipe, would offer the same resistance as 8 yards of round pipe, having an equal size or area of section; when the same quantity of air passes through them in a given time.

It is true that the friction of air or gas, in passing through the same pipe or air-way, varies in just the same degree that the density of the air or gas may vary; but in air-ways in coal-mines, the air has always nearly one and the same density, and it is only in particular calculations that it becomes requisite to notice its changes of density, in reference at least, to this part of the general subject, they are so small in amount. This is the case as regards friction, but the effects of variations in the density of the air circulating in mines are more sensible in producing pressure, operating either in favour of, or against the ventilating pressure, in rise or dip workings; but these effects belong more especially to another part of the subject. In an air-way 5 feet square, the perimeter of the section is $4 \times 5 = 20$ feet; and if it is 1000 feet long, the rubbing surface is $20 \times 1000 = 20{,}000$ square feet. In an air-way 10 feet square, the perimeter of the section is $4 \times 10 = 40$ feet; and if it was 1000 feet long, the rubbing surface would be $40 \times 1000 = 40{,}000$ feet; so that on comparing

the two cases it will be apparent that for four times the area there is only two times the extent of rubbing surface. If such an air-way as that last mentioned, (10 feet square, and having a rubbing surface of 40,000 square feet for every 1,000 feet in length) were divided into four equal sized square air-ways, the rubbing surface, exposed to the moving air, would be exactly doubled by the division; and there would be 20 feet of perimeter, for each of the four air-ways; or 80 feet on the whole; so that for a length of 1,000 feet, the rubbing surface for the four small air-ways, would be 80,000 square feet; or, exactly twice as great as that for the one large air-way; although the united areas of the smaller air-ways would be exactly equal to that of the single large one. In one case there would be a single air-way, 100 feet in area; and in the other, four smaller air-ways, each 25 feet area; but the rubbing surface, and therefore the friction, and the pressure required to overcome it, for the same gross quantity of air, would be twice as great in the four small, as in the one large air-way, having the same area. And from this fact, we learn that one large air-way is preferable to a number of smaller ones, even if they together make up the same sectional area or size. In practice, it often happens, however, that a number of small air-ways can be made and maintained, at less cost than one large air-way, presenting an equal sectional area; and, in such cases, a few extra air-ways, of small area, may more than compensate in utility, and make up in cost, for the absence of one extra-sized air-way; and hence the futility of insisting upon the sectional area of air-ways in mines being of any particular amount, without specifying their number; beyond requiring that one at least in each split be large enough to admit of persons travelling in it. The same principle may be illustrated by taking two air-ways of equal size or sectional



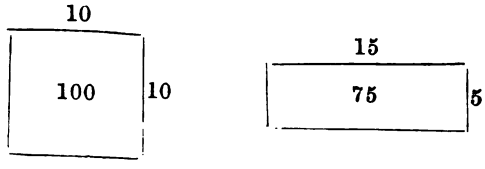
area, but having different forms or shapes of section; supposing one of them to be 10 feet high and 10 feet wide, its size or area of section would be 10 x 10 = 100 feet; and supposing the other air-way to be 20 feet wide, but only 5 feet high, the area would be the same, (or 5 x 20) 100 feet.



The air-way 10 feet square would have a perimeter of section 4 x 10 = 40 feet; while the other would have a perimeter of (20 + 20 + 5 + 5) 50 feet, compared with only 40 in the former; so that for equal lengths, the friction of the air would only be 40 in the square air-way, compared with 50, in the oblong one; and the friction in 50 yards of length, in the square shaped air-way, would be no more than that for 40 yards of length in the oblong one for the same quantity of air. Since the air in a mine presses with nearly the same force upon every square foot, it is quite natural that the frictional resistance should be greater or less in amount, to the same extent that the rubbing surface or number of square feet exposed to the air, is greater or less; and this is the general law or principle that has just been stated and illustrated by examples.

The pressures employed to ventilate mines, are commonly reckoned at so much per square foot of area; and not by the entire pressure employed, which is equal to the number of square feet, multiplied by the pressure on each square foot of sectional area, in the shaft or air-way. For instance, a ventilating pressure of 10 lbs. to the square foot on an air-way 100 feet in area, is equal, on the whole, to 10 x 100 = 1,000 lbs. If the same pressure of 10 lbs. per foot is applied to an air-way of only 50 feet area, the total

pressure is only 10 X 50 = 500 lbs.; owing to the area being one half, the total or gross pressure is also only one half. In order to get the same total pressure, we must make the pressure per foot greater in the same proportion that the area is less, when the rubbing surface and *velocity* of the air are to be the same in two cases. If we reckoned ventilating pressure by its total amount, we would not require to notice this law, it is so self evident; and it is only because we speak and treat of it, as so much pressure per *square foot*, that we require to consider the number of square feet to which it is applied. If there were two air-ways, one just twice the area of the other, the *velocity of the air*, and *the extent of rubbing surface*, being the same in each; then, we must apply twice the pressure to each square foot of the small one, that is required by the larger one, to overcome the equal amount of friction in the two air-ways, the quantity of air passing in the smaller one being just one half of that in the larger. As an example, if we had an air-way 10 feet by 10 feet, the area would be 100 feet; and the perimeter of section 40 feet: and another air-way, 5 feet high by 15 feet wide, the area would be 75 square feet, or just ¾ of the area of the



former; the perimeter of section would be, however, exactly 40 feet, in both air-ways. In the larger air-way, we would only require to employ 3-4ths of the pressure, on each foot of surface, (that is to say, 3-4ths of the water-gauge) that we would require to employ on each foot of the smaller area, so as to make up the same total ventilating pressure—the rubbing surface, for an equal length of air-way being the same in the two cases; because the perimeter of their sections are equal—the velocity of the air being taken as the same in the two cases—the quantities of air per

minute, would be simply proportional to their respective areas, under these circumstances.

This second law relating to the friction of air in mines, need not have been noticed at all if we had reckoned ventilating pressure as a whole; but as we generally speak of it as so many pounds per foot, we must also take into account, as has previously been remarked, the number of square feet to which it is applied; that is, the area of the section of the air-way; in the same manner that the area in inches of the cylinder or piston of a steam engine, multiplied by the pressure on each square inch, gives the total force applied to the piston. An inch of water-column, as shewn by a water-gauge, represents a pressure of about 5·2 lbs. per square foot.

The third general law relating to the friction of air in mines, is, that the pressure required to overcome the friction in the same air-ways, *varies*, (that is to say, increases or decreases,) in the same proportions that the *square* of the velocity of the air increases or decreases; so that a double velocity of air, in the same air-way, meets with a *double double*, or fourfold resistance; a treble velocity meets with a *treble treble*, or ninefold resistance; and a velocity of four times as great, gives rise to a resistance four times four, or sixteen times as great. In the same way, a half velocity meets with one half of a half, or 1-4th of the resistance; 1-3rd of the velocity encounters only a third part of a third, or 1-9th of the friction, and so on.

The third law of friction, at first sight, looks rather complex. Consideration, however, shews it to be quite natural; because, if we double the velocity of the air, in the same air-way, we, in the first place, cause twice the quantity of air to meet the resistances in a given time; and, in addition to this, every part of this double quantity meets every resistance with a double velocity or mo-

mentum; the double quantity of air, and the double velocity taken together, may well be supposed to give rise to a *double double* or fourfold resistance; and this is the true law. Again, if we treble the velocity of the air, we thereby cause three times the number of particles to meet the resistances in each moment of time, and this alone should treble the resistances; but, in addition to this, the treble quantity, meets with the resistances with three times the speed or momentum, which *trebles the threefold* resistance that arises from the threefold number of particles of air that meets the resistances each moment of time; on the whole, making a ninefold resistance, for a threefold quantity of air, in a given time.

The laws of ventilation would be very simple, quite as simple, indeed, as they are natural, were it not that, in lieu of the mere quantity of air circulating, in a given time, or the mere velocity of the air, we must make use of the square of the quantity, or, what is the same, the square of the velocity, in our calculations; and, as a matter of course in calculations for comparative results, if we employ the squares of the quantities or velocities, we must expect, as results, not the quantities or the velocities, simply, but their squares; and therefore it will be necessary to extract the square roots of the results so obtained, in order to get at the simple quantities themselves.

It has already been stated, that there is one other principle bearing on the friction of air passing through mines; to the effect that it is greater or less, in the same proportion that the density or weight of each cubic foot of air, is greater or less; so that if each cubic foot of air had a double weight, it would have a double amount of friction; or, if it had only half the weight, it would have only half the amount of friction, in the same air-way, when the velocity or the number of cubic feet per minute, is the same; but the variations in the density of the air in mines are so very small, compared with the

whole density, that the effects of this law on the amount of ventilation are very small; so small, indeed, as to be practically unfelt, at any rate, as an increase or reduction of friction in the moving air; even in an upright or vertical shaft, the density of the air would only be altered on the average by about 1-60th part of its amount, compared with a level air-way, supposing the shaft to be 150 fathoms deep, so far as the pressure of the atmosphere is concerned. The changes of density arising from the heat of upcast shafts, in expanding the air, has a greater effect, so far as such shafts alone are concerned, under furnace ventilation; but this does not affect the friction of the air in the workings of the mine; and, even in these shafts, the lessened density, arising from expansion by heat, has its effects on reducing the shaft friction, greatly modified by the greater velocity due to the increase in the volume of the air; this increased velocity does more than make up, by the accompanying increase of friction, for any reduction in such friction that is due to the lessened density of the air, in every case; the friction, in fact, increases or decreases in just the same proportion that the volume of a given weight of air increases or decreases; whether the change of density arises from change of temperature or from change of pressure. Supposing the temperature of the air in a mine to be 60° in winter, and 65° in summer, on the average, such a change would only alter the friction in such mine by about 1-104th of its amount; in summer the friction would be 1-104th greater than in winter, for the same weight of air; but it would, at the same time, be about 1-104th part less, for the same volume of air; an alteration hardly worth notice for the present purpose. The total friction, or the total pressure due to the friction of air rubbing against the top, bottom, and sides of the air-ways of mines, is not very well ascertained; all the experiments, at least all that have come under my notice, as having been made for the purpose, have been in some respects, of a rude character; the necessary particulars not being given in the accounts published, to fix with rigid accuracy its amount.

From the best accounts of such trials, it seems probable that for every foot of rubbing surface, and for a velocity in the air of 1,000 feet per minute, the friction is equal to 0·26881 feet of air column of the same density as the flowing air, which is equal to a pressure, with air at 32°, of 0·0217 lb. per square foot of area of section; calling this the *co-efficient of friction*, we have the following rules with respect to the friction of air in mines—

Total pressure	pa	=	ksv^2	(1)
Rubbing surface	s	=	$\frac{pa}{kv^2}$	(2)
Velocity squared	v^2	=	$\frac{pa}{ks}$	(3)
Co-efficient of friction	k	=	$\frac{pa}{sv^2}$	(4)
Pressure per foot	p	=	$\frac{ksv^2}{a}$	(5)
Area of Section	a	=	$\frac{ksv^2}{p}$	(6)

Where p = pressure per sq. foot.
a = sq. feet of sectional area.
s = the area of rubbing surface exposed to the air.
v = the velocity of the air in thousands of feet per minute—1000 ft. per minute being taken as the unit of velocity.
k = the co-efficient of friction in the same terms or unit as p is taken in.

Putting these formulæ into words, we have the following set of rules—

(1) *To find the total pressure* due to friction.*—Multiply the co-efficient of friction, by the extent of the rubbing surface, and the product, by the square of the velocity in thousands of feet per minute; that is to say, by the square of the quotient resulting from dividing the velocity in feet per minute by 1000.

(2) *To find the rubbing surface.*—Divide the total pressure by the product of the co-efficient of friction, and the square of the velocity in thousands of feet per minute.

* The *total pressure*, in these Rules, is found by multiplying the sectional area of the air-way, in feet, by the pressure per square foot.

(3) *To find the velocity.*—Divide the total pressure by the product of the co-efficient of friction, and the rubbing surface—this gives the square of the velocity—the square root of which is the velocity itself, in thousands of feet per minute; this multiplied by 1000 will give the velocity in feet per minute.

(4) *To find the co-efficient of friction from experiments.*—Divide the total pressure by the rubbing surface, and the square of the velocity (in thousands of feet per minute) multiplied together.

(5) *To find the pressure on each foot of section.*—Multiply the co-efficient of friction, the rubbing surface, and the square of the velocity (in thousands of feet per minute) all into each other; and divide the product by the area of the section.

(6) *To find the area of the section.*—Multiply the co-efficient of friction, the rubbing surface, and the square of the velocity (in thousands of feet per minute) all into each other; and divide by the pressure on each foot of sectional area.*

The foregoing rules embrace only the pressure due to friction, and not that due to the creation of velocity; so that they may be regarded as being true of long pipes and air-ways, as they are given; but as requiring an allowance for the pressure due to velocity in short pipes and air-ways:—this allowance renders the rules much less simple.

Now these rules, which are found out by practical trials, or experiments, lead us to many very important conclusions in reference to the best mode of conducting the ventilation of mines; in proof of which, it would be easy to multiply examples.

* If it is preferred to employ in these rules the velocity in feet per minute, in lieu of in *thousands* of feet per minute, the co-efficient of friction, in lieu of ·268,81 would become ·000,000,268,81; and if the velocity is taken in feet per second it would become ·000,967,716.

These laws of friction may be illustrated by the following example—

In an air-way 10 feet square = 100 feet area, and 25,000 feet, or nearly five miles long—if the velocity of the air were 1 foot per second, or 60 feet per minute, the quantity of air would be 6,000 feet per minute—the pressure due to friction (taking the pressure at 14·7 lbs. per square inch, and the temperature at 32°) would be ·7812 lbs. per square foot of sectional area of the air-way; the horse-power being ·142.

In another air-way of equal length, but instead of being 10 feet square, only 5 feet square, giving only 25 feet or 1-4th of the area of the larger air-way, we have the following results—The rubbing surface in the small air-way would only be one half of that in the large one; but, on the other hand, the area to which the ventilating pressure would apply would only be 1-4th; and at the same time, the velocity of an equal volume of air would be increased fourfold in the lesser air-way; this increase of velocity alone making sixteen times the friction, so that on the whole it would be thirty-two times as great; making the pressure on each square foot 24·998 lbs., being thirty-two times as great as in the large air-way. And, therefore, on the whole, the *power* expended would be also thirty-two times as great—in the small as in the large air-way, for the same amount of ventilation per minute—the coals consumed would also be thirty-two times as great. If furnace ventilation were used, and the heat of the upcast shaft and pressure per foot were the same, instead of 6,000 cubic feet per minute, as in the large air-way, we should only have 1,061 feet in the smaller one; but, in this case, the coals burnt would only be $\frac{1}{\sqrt{32}}$, or between 1-5th and 1-6th of the former quantity, and the power would be less in the same proportion, for the lesser quantity of air. This shows in a striking manner the great advantage of large air-ways.

The calculations relative to the two cases compared with each other for the example just given stand thus :—

FOR THE LARGE AIR-WAY.

The length is 25,000 feet, and the perimeter of section is $4 \times 10 = 40$ feet; so that the rubbing surface

$$s = 40 \times 25{,}000 = 1{,}000{,}000 \text{ square feet,}$$

the area $a = 10 \times 10 = 100$ square feet,

the velocity $v = \frac{60}{1{,}000} = \cdot 06$, in thousands of feet per minute,

and $k = \cdot 268{,}81$, being the co-efficient of resistance, in feet of air-column of the same density as the flowing air.

Now by formula (5) we have

$$p = \frac{k s v^2}{a}$$

giving in this case

$$p = \frac{\cdot 268{,}81 \times 1{,}000{,}000 \times (\cdot 06 \times \cdot 06)}{100} = 9 \cdot 67716$$

feet of air-column as the pressure required.

Taking the flowing air to have had the density due to a temperature of 32°, and to a pressure of 14·7 lbs. per square inch, a cubic foot of it would weigh ·080728 lb., and therefore such a column would represent a pressure of

$$9 \cdot 67716 \times \cdot 080728 = \cdot 7812 \text{ lb. per square foot;}$$

and hence the horses' power due to the friction of 6,000 cubic feet of air per minute, in passing through such an air-way, would be

$$\frac{6{,}000 \times \cdot 7812}{33{,}000} = \cdot 142, \text{ or about 1-7th of a horse power.}$$

FOR THE SMALL AIR-WAY.

Proceeding as in the former case, we have

$$\frac{\cdot 26881 \times (20 \times 25.000) \times (\cdot 24 \times \cdot 24)}{25} = 309 \cdot 66912$$

feet of air-column, as the pressure required for putting the same quantity of air, 6,000 cubic feet per minute into circulation; being equal to a pressure of

$$309{\cdot}66912 \times {\cdot}080728 = 24{\cdot}9989 \text{ lbs. per square foot; giving}$$

$$\frac{6{,}000 \times 24{\cdot}9989}{33{,}000} = 4.545 \text{ horses power.}$$

If the *pressure per square foot* was the same in the small as in the large air-way, or ·7812 lb. per square foot, the air-column would be $\frac{{\cdot}7812}{{\cdot}080728} = 9{\cdot}67716$ feet high; and the square of the velocity (in thousands of feet per minute) would by formula (3) be

$$v^2 = \frac{9{\cdot}67716 \times 25}{{\cdot}268{,}81 \times (20 \times 25000)} = {\cdot}0018$$

and hence the simple velocity, in thousands of feet per minute, would be

$$v^2 = \sqrt{{\cdot}0018} = {\cdot}042426$$

and the velocity in feet per minute would therefore be

$${\cdot}042426 \times 1{,}000 = 42{\cdot}426:$$

and this gives for the quantity of air that would be put into circulation in the small air-way, by the same pressure per foot that is required to circulate 6,000 cubic feet per minute in the large one,

$$42{\cdot}426 \times 25 = 1{,}061 \text{ cubic feet per minute, as has been stated.}$$

To circulate 1,061 cubic feet of air per minute in the small air-way would, however, only involve the application of

$$\frac{1{,}061 \times {\cdot}7812}{33000} = {\cdot}0251 \text{ horse power,}$$

which, under the conditions of the small air-way, and the assumed pressure, represents the entire power due to the friction of the quantity of air that would circulate in it.

Air, in being heated under a constant pressure, expands 1-459th part of its volume at the temperature of zero of Fahrenheit's thermometer, for each degree of temperature imparted to it: 459

cubic feet of air, at 0°, become 469, at 10°; 479 at 20°; 489 at 30°; and so on. 1,000 cubic feet of air at 32°, the temperature of melting ice, expand to 1366½ cubic feet, at 212° the temperature of boiling water. To find the relative volumes occupied by equal weights of air, under equal pressures, but at different temperatures; we have simply to add the constant number 459 to the temperatures, and the sums give the relative volumes. The ordinary pressure of the atmosphere is equal to that of a column of water, about 34 feet or 400 inches in height; we, however, seldom employ a difference of pressure of more than 2 or 3 inches of water column, as ventilating pressure in mines. The pressure of the air is about 2116 lbs. per square foot, but we seldom employ more than 10 to 17 lbs. extra as ventilating pressure. Owing to the ventilating pressures being so small, the changes of density in the air of mines, (as it circulates) arising from changes of temperature, the mixture of watery vapour or steam, the gases given off, and one or two other causes, give rise to small local pressures in the various splits of air, in a mine. In rise splits, these local pressures usually operate against the general ventilating pressure, and lessen the quantity of air that would otherwise circulate. In dip splits, these small local pressures commonly act in the same direction as the general ventilating pressures, and so add to the amount of their ventilation. This arises from the return air of any split being generally less dense than the intake air.

The laws of ventilation lead us to conclude that if we increase or decrease the total ventilating pressure, and total quantity of air circulating in a given time, where the seam of coal is perfectly level, each way or split will get a *fixed share* of the whole of the air entering the mine; no matter how long or short may be the different splits, and no matter how great or small may be the quantity of air. This is contrary to an old notion, that a short split gets an increasing and a long one a decreasing share of any

lessened amount of ventilation, apart from considerations as to the rise or dip of the seam. Not long ago, this point was severely tested by numerous experiments, at several collieries; the results shewed that the old idea was a mistaken one, and that the only changes that took place in the *proportion or share* of air going to different splits, with a reduced ventilation, arose from their relative rise or dip, together with the relative densities of the intakes and returns; and had no connection with the mere lengths of the splits. In ordinary cases, where the air of the returns is less dense than that of the intakes, if we have a short level split regulated so that, with the full ventilating pressure, it gets the same amount of air as a long dip split; and, if we then halve the total quantity of air circulating, we find that the short level split no longer gets its share, but only a quantity less than that which goes into the long dip split; the very reverse of this is the case where the long split is a rise one; and these results are perfectly agreeable to the laws of ventilation that have been stated. In practice, and with the ordinary splits of air used in mines, except in extreme conditions, as to the amount of rise and dip, and changes of density in the air, and in the amount of ventilation, the *share or proportion* of air going into the different splits of a mine, are nearly maintained, whether we increase or lessen the total amount of ventilation; and any deviation from this depends upon the rise or dip of the splits, and not at all upon their relative lengths. In practice, then, when any reduction of ventilation has been brought about, we should generally find that the rise splits have been more affected than dip ones, if even the rise splits are shorter than the dip ones; and should therefore expect to find accumulations of gas in the short rise splits, rather than in the long dip splits of the mine. The greater the rise, the greater is the danger of this, quite apart from the mere length of the splits, supposing them to be equally well ventilated to begin with.

So far as experiments have gone, they show that if we had a

series of equal-sized, and similarly-shaped air-ways, made of different substances, the friction of air in passing through them, would differ according to the nature of the substances.

Taking the friction in earthenware pipes at...	100
In the air-ways of mines it would also be	100
In sheet-iron pipes, new and clean.....	39
In ..... do. ..... rusty inside.....	10
In cast-iron pipes, sooty inside.....	20
In ..... do. ..... tarred inside	18
In tin pipes the friction would only be	10

So that 1-10th of the pressure would send the same quantity of air through a tin pipe that would be required to force that quantity of air through an earthenware pipe of the same size, in the same time.*

From these laws we learn that the quantity of air that will pass through any mine, is greater or less, as the ventilating pressure is greater or less—but not in the same proportion. When the air-ways are the same, the quantity of air only alters in the proportion of the square root of the pressure; so that a four-fold pressure, only gives a double quantity of air; and a ninefold pressure, only gives a treble quantity of air. But, on the other hand, one fourth of the pressure still gives one half of the air; and one ninth of the pressure gives one third of the air. The changes in the quantity of air, then, are sluggish as compared with the changes in the ventilating *pressure;* only varying as its square root. The quantity of air, however, is more sluggish still in reference to the *power* employed to cause it to circulate. The quantity of air only varies as the cube root of the power, and of the quantity of coals burnt to produce it; so that eight times the coals only double, and twenty-seven times the coals only treble the quantity of air circulating in a mine; whether the ventilation is

* See Table, following page.

Table showing the values of the co-efficient of friction, represented by the letter k, in the formulæ given at page 258; being the height in feet of air column, of the same density as the flowing air, required to overcome the frictional resistance encountered by 1,000 cubic feet of air per minute, in passing through a passage having one foot of sectional area, and presenting one square foot of rubbing surface to the air in motion.

Nature of the material composing the pipe or air-way.	State of the internal or rubbing surface exposed to the wind.	Observers' names.	General temperature of the air or gas.	Head of column of the same density as the moving air or gas required to overcome the friction; being the co-efficient of friction $= k$.	Remarks.
Burnt earth.	Clean.	Péclet.	Hot.	0·268,81	In applying these values of k to the formulæ at page 258; since they are calculated for velocities of which the unit is 1,000 feet per minute; the real velocities in feet per minute must be divided by 1,000, to give the value of v in the formulæ; and v in the formulæ must be multiplied by 1,000 to give the velocity in feet per minute.
Galleries of a coal-mine.	Ordinary state.	G. C. Greenwell.	Cool.	0·254,36	
Sheet iron.	New and clean.	Péclet.	Hot.	From 0·105,83 to 0·067,73	
Cast iron?	Ordinary?	Mons. Rudler.	Hot.	0 084,66	
Cast iron.	Sooty.	Péclet.	Hot.	0·052,92	
Cast iron.	Old, Tarred	Girard.	Cool.	0·048,44	
Gas in pipes. } cast	Ordinary.	Mr. Hawkesley.	Cool.	0·030,14	
Water in pipes. } iron.	Ordinary.	Eytelwein.	Cool.	0·030,28	
Sheet iron.	Old and rusty.	Girard.	Cool.	0·027,52	
Tinned iron.	?	D'Aubuisson.	Cool.	0·025,40	

produced by furnace-action, ventilating machines, or otherwise, so long as the air-ways remain in the same unaltered state. From this we learn that we must not expect any great general improvement in the ventilation of mines from a mere increase of power; any increase in the quantity of air in the same air-ways, is slow, small, and costly, compared with the necessary increase of power required to produce it.

In the same manner, these general laws show us that the quantity of air increases as we decrease or lessen the extent of the frictional rubbing surface; but again, not in the same proportion, but only as the square root of the extent of the rubbing surface. If we could do away with three parts out of four of the rubbing surface, so as to reduce it to 1-4th, other things being the same, we should only double the quantity of air in the mine; if the rubbing surface were reduced to even 1-9th, the quantity of air circulating per minute would only be increased to three times its previous amount. On the other hand, if the extent of workings and rubbing surface were increased to four times, or nine times their previous amount, while the area of the air-ways and the ventilating pressure remained unaltered, the air would only be lessened to one half or one third of its previous amounts, respectively, by such extensions; if we suppose the size of the air-ways and the number of splits of air to remain the same—as well as the ventilating pressure—in each case.

From these laws, then, we learn that either to increase the ventilating pressure, or to lessen the extent of rubbing surface exposed to the air circulating in mines, are very slow, and very costly modes of proceeding to increase the amount of ventilation, as the quantity of air circulating in a given time, alters so slowly, with any alteration that may be made in the ventilating power or pressure; or, in the mere extent of rubbing surfaces that may be presented to it. For general improvements, we must therefore

look chiefly in some other direction, owing to these being slow and costly modes of increasing the ventilation of a mine.

The same general laws of resistance, show us that if we could reduce the velocity of the air, consistently with increasing the quantity circulating in a minute, we should greatly lessen the friction in comparison with the quantity of air circulating; and so obtain an increased quantity for the same amount of friction, or by the same ventilating pressure. This object is accomplished by splitting the air, so that, instead of allowing the whole of the air to traverse the whole of the workings, a separate portion is taken into each different district of workings, and also brought out in a separate channel, to near the upcast shaft, after it has done its work. The air, as a whole, thus has as many ways to go in, and as many to come out by, as there are separate splits in the mine; the extent of the rubbing surface is not lessened by this, on the whole, but the area offered to the air is greatly multiplied; and although the velocity of each current may be reduced, still, on the whole, the quantity of air in all the splits is very much greater than if there were only one single current in the mine; even when the ventilating pressure is the same. Splitting the air does not necessarily enlarge the area offered to the air in the shafts, and the increased resistance arising from the increased quantity and velocity of air in them, sets a limit to the benefits resulting from splitting the air in a mine. Owing to the resistance offered by the shafts, we dare not have more than a limited number of splits in a mine, because although every split adds to the total quantity of air circulating, still, in each separate split the quantity ultimately becomes less and less; and if the number be too great, the current of each becomes too feeble and slow to sweep into the holes, corners, and places driven in advance of the actual current; and besides this, powder smoke is a long time in being carried away from the workmen. Still it is a fact, that an additional quantity of air, on the whole, is obtained from every new split that is made.

The following general rules should be observed in splitting the air in mines :—

Every principal split of air should commence as near as possible to the bottom of the downcast shaft; and should have a distinct air-way to return in, as nearly as may be, to the furnace or the bottom of the upcast shaft; except in cases where it is necessary to mix different currents lest some one or more of them may be dangerously charged with gas. Splits of air only commencing far into the workings of a mine, have comparatively little effect in increasing the quantity of air.

Where the air-ways are nearly of the same area in all parts of a mine, and the gases given off, and the workmen employed, are pretty evenly distributed, the length of the runs of the different splits should be as nearly equal to each other, as circumstances may permit; the observance of this rule has a tendency to render regulators and other obstructions, comparatively needless, and so to increase the amount of ventilation.

If we have a lot of splits of air in a mine, each with an equal amount of air, then it is necessary so to obstruct each of the shorter splits as to cause their frictional resistances, when they have their proper share of air, to be as great as that of the very longest split, when it also has its due share; otherwise they would get too much air, and the longer ones too little. These obstructions, of course, lessen the total quantity of air circulating.

The increased quantity of air obtained by splitting, depends greatly upon the relative depths and areas of the shafts, as compared with the lengths and areas of the air-ways forming the workings of the mine. Supposing a mine to have such shafts and air-ways, that when there are five equal splits of air, the shaft resistances amount to one half of the resistances offered by the mine—and this is no

uncommon case—then, if before splitting the air at all, we had a ventilation of 10,000 cubic feet of air per minute, the following are the quantities of air that would circulate, by increasing the number of equal splits, while the entire extent of the workings, and the heat of the upcast shaft, and the ventilating pressure, all remained the same.

No. of currents	Quantities of air on the whole.	Quantities in each split.
1	10,000	10,000
2	27,802	13,946
3	49,449	16,480
4	71,527	17,882
5	90,789	18,158
6	107,800	17,966
10	141,710	14,171

In this case, the coals burnt, whether in a furnace or by an engine driving a ventilating machine, would increase in the same proportion that the quantity of air increased; because the power would increase in that ratio. If the coals burnt, and the power remained unaltered, the results would only be as below:—

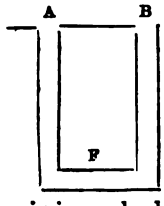
No. of currents.	Total Quantities of air per minute.	Quantities of air per minute in each split.
1	10,000	10,000
2	19,813	9,906
3	29,022	9,674
4	37,121	9,280
5	43,736	8,747
6	48,797	8,133
10	58,556	5,856

Enlarging the sectional area or size of air-ways has a great effect in increasing the ventilation, but it is attended with great cost, and in general terms may be said to be much less effectual than judiciously splitting the air into a series of different currents. The beneficial effects of splitting air, are, I believe, more fully appreciated, and the practice more extensively followed in the Newcastle coal-field, than in any other mining district; but,

even there it too often happens that the splits are made too far from the bottom of the downcast shaft, and are again brought into the same return, too soon after they leave the face of the workings. This often arises from pillars being worked away near the shafts, without proper places being left to make additional air-ways leading to and from the more distant parts of the mine. This is a very common oversight, and often entails either danger or a serious outlay, which might be avoided by care and forethought.

On the Means of Applying Power or Pressure to Produce Ventilation.

We have seen that *pressure* is required to put air into motion, and, more particularly, to overcome the friction it meets with in rubbing against the top, bottom, and sides of the galleries in mines. We have next to consider the means employed to give rise to this ventilating pressure. There is constantly a pressure of nearly a ton to the square foot, in every direction in the air near the surface of the earth, owing to the weight of the air above it; and we must either increase or lessen the amount of this pressure, in order to put the air into motion; and it is only the amount of this increase or decrease, and not the entire pressure, that puts the air into motion, and overcomes the friction in mines.



Take the case of two pits or shafts, of equal depth, and having their tops and bottoms on the same level, and filled with stagnant air, which likewise occupies an opening, extending from the bottom of one shaft, to the bottom of the other; and suppose, that in the first place, the weight of air in each shaft is the same as that in the other; the temperature and other conditions being the same in each; and that the shafts are of the same sectional area or size. In this state, the two columns of air exactly counterbalance and support each other, so that there is no motion in the air, and therefore no ventilation is produced; nay,

further, if one shaft be ever so much larger than the other, the air it contains can only press upon that in the smaller one, over the area of the smaller section; the air contained in the extra size of the larger shaft, resting or pressing upon the sides of the shaft or air-way, at the place where the area is lessened; and not upon the air in the smaller shaft; so that whatever may be the relative sizes of the shafts, the air in the one will balance that in the other, if the density of the air is the same in each; this may be termed the pneumatic paradox, If, however, by means of a furnace, at F in the diagram, the air in one shaft is heated and expanded, it becomes lighter, bulk for bulk, than the cool air in the other, and no longer balances it; the pressure of the heavier air, then overcomes that of the lighter air, and pushes it up the shaft before it, while the cool air from the cool shaft takes its place; not in a cool state, as it gets heated in its turn, in passing over the furnace; so that there is a continual current of cool air going down one shaft, which pushes before it a constant current of hot air, up the other shaft.

In mines, the air instead of being allowed to go direct from the bottom of one shaft, to the furnace, and up the other, is guided by means of stoppings and doors, into and along the various passages forming the workings of the mine, before it is brought upon the furnace or into the upcast shaft; and, by this means, a continual stream of air is made to sweep through the workings, and mix with and carry off the gases, as they are given off; and this is called the ventilation of the mine.

In some cases, men, boys, and horses, require to travel in directions that the air is not wanted to go, and in such cases, we cannot build up the way, by a stopping; but have to place doors to stop the passage of the air; in many cases the opening of a door to allow a person or horse to pass, would have a bad effect by allowing the air to pass through it even for so short a time, and to avoid

this evil, two doors are employed, so that one may always be closed, when the other is open. The use of doors in the principal roads of mines is objectionable where it can be avoided; and is much less common, at least in some districts, than formerly; in other districts of the kingdom, the number of ventilating doors is very great, notwithstanding the danger and cost attending their use. The neglect of keeping doors shut has, no doubt, often led to serious explosions of gas in mines. In some cases it is necessary that the route of one split or current of air should intersect and cross that of another, and in such cases, one current is carried over or under the other by means of drifts or masonry to prevent their coming into contact with each other; this arrangement is called an air-crossing or bridge. When an explosion occurs, the force of the concussion often destroys air-crossings and thereby interrupts the ventilation; so that they should be avoided, as far as possible; and made very strong where they are used in fiery mines.

It has already been stated that, where there are several splits of air in a mine, of different lengths, and offering different resistances, we sometimes find that too little air goes into the longer splits, compared with the quantity going into the shorter ones; and, in order to correct this evil, we put regulators or contractors into the shorter ones, so as to increase the natural resistance they offer, and cause more air to go into the long splits. Regulators, although useful where they are unavoidable, are not desirable; as they contract the air-ways, and so lessen the total quantity of air circulating in the mine, in a given time. As far as may be, the routes of the air should be so proportioned that each split may obtain its proper share of air, without using any artificial regulators. Doors, air-crossings, and regulators should be avoided in all cases where the circumstances of the mine admit of it.

In order to find the amount of ventilating pressure, and the

power arising from the use of a ventilating furnace, we require to know the weight of a cubic foot of air at different temperatures and under different pressures. Careful experiments show that 459 cubic feet of air at 0°, or zero of Fahrenheit, the common thermometer, weigh 39·76 lbs., when the pressure is 30 inches of mercury of the density due to 32° ;—a pressure equal to nearly 14¾ lbs. per square inch, which is the ordinary pressure of the atmosphere—but it only weighs 1-30th of this or 1·3253 lbs. when the pressure is only 1 inch of mercury; and since 459 feet of air at 0°, expand exactly a cubic foot for each degree of heat added, we get the following *rule* to find the weight of a cubic foot of air, at any temperature, and under any pressure—

$$W = \frac{1{\cdot}3253 \times I}{459 + t}$$

Where I = the height in inches indicated by the barometer, and t = the temperature by Fahrenheit's thermometer. At 38°, under a pressure of 30 inches of mercury, 100 cubic feet of air weigh just 8 lbs; a box 5 feet every way would just contain 10 lbs. of such air.

On one occasion, at Hetton Colliery, when 225,176 cubic feet of air per minute were circulating the average temperature of the air in the downcast shaft was 43½°, and that of the air in the upcast shaft was 211°. Now by the rule given (if we take the barometer half-way down the shaft to have shown a pressure of 30½ inches of mercury,) the weight of a cubic foot of air, taking the average, in the downcast shaft, would be ·08044 lbs.; and the pit being 900 feet deep, this air would produce a pressure of ·08044 × 900 = 72·396 lbs. on each square foot, by its mere weight. The air in the upcast shaft, owing to its being hotter, would be lighter, and only produce a pressure on each foot = 54·297 lbs.; and hence the difference of pressure on each square foot of area, between the two columns of air, would be = 18·099 lbs. Now in order to find the horses' power producing ventilation, we require to multiply this difference of pressure, of 18·099 lbs. on the square foot, by

the number of cubic feet of air circulating per minute; and then to divide the result by 33,000, the number of lbs. raised 1 foot high, per minute, by a horse power. In this case then we find the ventilating power at Hetton Colliery must have been

$$\frac{\text{lbs.} \quad \text{c. ft. pr. min.}}{18{\cdot}099 \times 225{,}176} = 123\tfrac{1}{2} \text{ horse power;}$$
$$33{,}000$$

225,176 cubic feet of air per minute being in circulation at the time. Some part of the extra heat of the air in the upcast over that in the downcast shaft, would have arisen from the heat of the mine, and would have caused what is called a natural ventilation, even if furnaces had not been used. But natural ventilation is generally very small in amount, and cannot be depended upon, as, in hot weather, the downcast column of air is little or no cooler or denser than the air in the upcast; and, by making the weight or pressure of the two air columns equal, is liable to stop all ventilation.

Where furnaces are used to produce ventilation, the deeper the upcast shaft the better; because this gives rise to a longer upright column of hot air, and so causes a greater ventilating pressure, and consequently a brisker ventilation. Furnaces are not well suited for causing ventilation in shallow pits, owing to this; and sometimes machines are fixed at the top of the pit to pump the air through the mine. These machines, for the most part, exhaust air out of the upcast shaft, and the pressure of the denser air in the other, or downcast shaft, causes the current. Such a ventilating machine, like a furnace, acts by rendering the upcast column of air lighter, bulk for bulk, than the air in the downcast shaft; the same effect is sometimes produced by large fans; the machines mostly being worked by steam engines. A few of these ventilating machines are used in the south of England, and in Wales, and a great number are used on the continent. Ventilating machines of the best construction consume less coals

(to produce the same quantity of ventilation), than furnaces—except in very deep and dry shafts. But coals are plentiful at collieries, and the liability of ventilation being suspended by the breakage of the machinery, and the inconveniences attending stopping the ventilating machine for repairs to itself or the engine, together with the difficulty of applying ventilating machines to working shafts, render them, in the opinion of many persons, less to be depended upon than furnaces, in general. Taking the average of eleven different collieries in the Newcastle district, each pound of coal puts 13,000 feet of air into circulation, by the action of furnaces. In some collieries, two or three times as much air is circulated, by each pound of coal, as in others; depending on the depth of shaft, and its state as to dryness or wetness; and on the friction of the air in the shafts and in the mine itself. There are, in Wales, some seven or eight ventilating machines at work, producing ventilations varying from 16,000 to 75,000 cubic feet of air per minute. The largest machine being one recently erected at Deep Duffryn Colliery, which, with air-ways of sufficient area, would be capable of producing a ventilation of double the latter quantity.

Jets of steam were proposed to produce the circulation of air in mines a few years ago, but by an elaborate series of experiments, their effects were found to be far below that of furnaces, and the cost to be very great; and the idea of their utility for ventilating mines was therefore abandoned. The useful work contained in a jet of steam probably varies as the cube of the velocity of the steam, so that if the same quantity of water was converted into steam, in a given time, the power contained in it would depend upon the smallness of the jet orifice it had to escape through; by halving the area of the jets we should obtain eight times the power, and should therefore get a double quantity of air through the same mine; by reducing the area of the jets to one third, we should obtain a treble quantity of air, by the same quantity of steam, in a

given time. At least these are the results given by calculations, made upon the principles of mechanics, which are found to be true for streams of water and air. I have not taken pains to compare them with the results of the experiments on steam jets as applied to ventilation; because the results seemed to hold out no hope of steam jets ever being made available for ordinary ventilation. There are no doubt temporary and peculiar circumstances, under which steam jets may be useful in the production of ventilation; such as cases where it is either unsafe or impracticable to use ordinary furnace action.

Falls of water are sometimes employed in downcast shafts to cause a current of air to descend; but, as the water has, for the most part, to be raised again from the mine, and as the effects they produce are small, in proportion to the power employed, this mode of ventilation is seldom used, except where furnace action or other means are necessarily excluded.

On the Instruments used in connection with the Ventilation of Mines.

Barometer.—The pressure of the atmosphere, in different states of the weather, varies from 28½ to 31 inches of mercurial column; being from 2016 to 2192 lbs. per square foot, and it is found that the natural discharge of gas, in mines, becomes greater, as this pressure becomes less; so that the reduced atmospheric pressure, as shown by a barometer, is a warning that an increased quantity of gas may be expected to be given off, in mines; and therefore calls for increased care and vigilance, to keep the ventilation at its greatest point, and for taking precautions against the enemy. The air pent up in goaves, and abandoned excavations, also expands in volume from the reduction of pressure which causes the fall of the barometer, the increase of volume being given out into the air-ways, and often being mixed with gases should be carefully watched, as the barometrical pressure of the atmosphere

is lessened; the more suddenly the pressure falls, the more observable are these results. A very *sudden* fall of the mercury is accompanied by a worse effect on mines, than a greater fall, provided it takes place less rapidly. An increase or decrease of the pressure of the atmosphere, has little or no effect in altering the *volume* of air passing through a mine in a given time; although it alters the *density* and *weight* of such air, often to a considerable extent.

A good portable barometer may be used to ascertain the friction of air in passing along air-ways; because the loss of pressure, by friction, as the air circulates, is always taken off the pressure of the air itself; so that in level air-ways, the air is less and less compressed as we proceed in the direction followed by the air; and the reduction of pressure is an exact measure, in such air-ways, of the pressure spent on friction. When the air-way rises or dips, allowances for this have to be made, in finding the amount of friction from the pressure of air, in this manner. Aneroid barometers appear to be better suited for use in mines than the common barometer or weather glass, as they are more portable, less liable to derangements, and almost equally reliable, at least for comparative indications, which are just as useful as absolute ones in mines.

Thermometer.—The thermometer is used to measure the heat of air in mines; when the fresh air, going down a downcast shaft, is heated, it expands and becomes lighter, and is, therefore, less able to force the air before it through the mine; in other words, by being heated, the weight of the column of air in the downcast shaft is reduced, till it is more nearly equal to that in the upcast shaft, and consequently the ventilating pressure is lessened; and, therefore, the quantity of air circulating is also reduced in amount. By the use of this instrument we find the difference of temperature between the air in the downcast and that in the upcast shaft, and so are able to calculate the ventilating pressure due to the action of a furnace.

Water Gauge.—The water gauge is merely a glass tube, bent into the form of the letter U with a scale of inches and parts, by which we can measure the difference between the height of the water in one tube and that in the other. It has already been stated that the air loses the pressure that is spent on the friction as it progresses along an air-way. Now, when an air-way happens to turn so as to come nearly parallel to itself, there is often a door or stopping, separating the two adjacent parts of the same air-way, and this instrument enables us, in a direct way, to measure the amount of pressure that is spent on friction between the two adjoining parts of the air-way so situated. The air has less pressure on the outcome or return side of the separation, than the air on the intake side, which has not yet met with the friction of the intervening distance of air-way. If the water in one leg of the tube is exposed to the pressure of the intake air, while that in the other is exposed to the less pressure of the return air, the greater pressure on the intake leg of the water gauge, sinks or depresses the surface of the water in that leg, and raises it in the other leg; the difference of level, which represents the ventilating pressure spent on the air-ways lying beyond the place where it is taken, is seldom so much as three inches, and often only one inch, in well ventilated mines. The amount of water gauge can be increased, either by increasing the ventilating pressure, and consequently, also the quantity of air circulating in a given time, while the air-ways are in the same state; or, it can be increased by falls of material, or other obstructions in the air-ways, even while they lessen the quantity of air circulating; because such obstructions increase the frictional resistance of the air, and the gauge is a measurer of that resistance. A water gauge does not show the shaft resistances, when used in a mine. The pressure shown by the water gauge is equal to the general shaft ventilating pressure, *less* or *minus* the friction due to the air in the shafts and in the air-ways extending from the shafts to where the gauge is tried. It is also a measure of the resistances the air meets with in the workings lying beyond it, *less* or *minus* any local force, arising from the air in the returns being lighter than that in the intakes, in dip-ways; or it is equal

to such friction added to any such pressure, that may operate against ventilation from the same cause, in the rise-ways or splits of air in the mine; and in cases where the air of the returns is more dense than that of the intakes, the effects arising from the dip or rise of the workings will of course operate in the reverse manner, upon the indications of the gauge. When the air-ways remain in the same state the amount of water gauge increases as the ventilation increases, and falls as it decreases; but the proportion of variation of the gauge-pressure, is much greater than that of the quantity of air circulating; the *square* of the quantity of air, except in so far as local pressures may interfere, is proportional to the pressure indicated by the gauge, because the friction varies as the square of the quantity of air.

The Anemometer is an instrument used to measure the rate at which the air flies in mines. That invented by the late Mr. Biram is the one mostly used in English mines; it is not a very easy matter to find how much each of these instruments require to be allowed for their own working friction, no perfect rule has yet been established for this purpose, although one is much needed. An approximate rule requires that a constant quantity should be added to the number of revolutions in a minute, no matter what may be the speed of the wind or of the instrument; and that the sum so obtained should be multiplied by another constant quantity, to give the velocity of the air in any terms in which we wish to find it. Coombes' anemometer can be put into or out of gear by pulling strings attached to it; this instrument is said to give very correct results, and is greatly used on the continent; it is however more troublesome to use than Biram's anemometer, and is seldom seen in our mines. There are a few other kinds of anemometers; but a good and simple instrument, or mode for finding the velocity of air in motion, has probably yet to be contrived.

The Hygrometer.—In fine experiments, the hygrometer is used to ascertain the proportion of moisture in the atmosphere of mines, from whence its density and also its capacity for heat are found. Mason's wet

and dry bulb hygrometer is better adapted for use in mines than the more delicate one of Daniel. The return air in nearly all mines is found to be saturated with vapour of water; that is to say, it contains the greatest quantity of vapour that can exist in it, at its temperature; and a portion of vapour is condensed by the least degree of cooling that takes place in the air. An atmosphere saturated with vapour, is lighter, bulk for bulk, than another at the same pressure and temperature, but containing less vapour.

Mr. Thomas Knowles proposed a vote of thanks to Mr. Atkinson for his paper, and to the President for reading it.—Mr. George Charlton seconded the resolution, and said the paper was a very valuable contribution to the Transactions of the Society, presenting as it did a full and complete view of the laws of the ventilation of mines. The vote was passed unanimously.

The President—I think those of you who were present at the last meeting will remember that Mr. Atkinson, in the opening of his first paper on this subject, said that it might be useful for young colliery viewers, underlookers, and workpeople who might wish to raise themselves; and there is doubt it will be useful to those; but I think, if his modesty had not been so great, he might have said it would form the most useful book of reference that we have as yet published on the subject of the ventilation of mines. I know of no elementary treatise in which the subjects are so well brought forward, and so many tables given, which will be valuable not only to the beginner but to the viewer as a book of reference.

Mr. Joseph Goodwin—There is one thing I should like to ask Mr. Atkinson, namely, whether I understood him rightly to say that

the length of the splits had nothing to do with the quantity of air passing through them.

Mr. J. J. Atkinson—No. Supposing you have a long split and a short one in the same mine, and you regulate or contract the short one by an artificial obstruction, until the quantity of air going into each is equal. Then supposing, from some cause or other, the general ventilating pressure is gradually reduced, what would be the result? Would the short split get half of the remaining total quantity of air, or would it get less or more? That question would have been answered in my younger days by saying that the short split would ultimately take the whole of the air, and none would go to the long one. Now, however, it is a fact, which I have proved over and over again, that if the air-ways are level, and you reduce the ventilating pressure, each split will take its original *proportion*; but if the long way is a dip way and the short way is a level one, on reducing the gross quantity of ventilation, the long-way gets more than its original *share* of the reduced quantity, and so takes the lead of the short split. If, on the other hand, the long split is a rise and the short a level, on reducing the gross quantity, the long split gets less and the short one gets more than its *share*. Supposing one split gets 60 per cent. and the other 40 per cent. of the total to begin with—if the air-ways are level, each will get the same per centage when the gross amount is lessened. Just the reverse results take place if you take the proportions from any standard amount of ventilation, and then *increase* the gross quantity, where there are rise and dip splits—supposing the air in the returns to be hotter and less dense than in the intakes in each case. If, however, the returns were so mixed with carbonic acid gas, and so cool as to be more dense than the air in the intakes, then the reverse results would ensue on increasing or reducing the ventilating pressure, where the splits are not level.

Mr. Goodwin—I am quite satisfied with the explanation.

The President—I am glad you put the question, Mr. Goodwin, for this is a point that is not sufficiently understood.

Mr. J. J. Atkinson—We had a long discussion about this at the Northern Institute. Some one there suggested, after the Lundhill accident, that instead of having air kept so much in one current, if they had taken it up each bank in separate splits, they would have got a much better ventilation. Some one else said "yes; but in the event of the furnaces being low and the general ventilation being reduced, the far off places would get no air; it would all run through the short cuts;" and it was to correct that idea that the matter was made the subject of investigation, by careful experiments.

Mr. Goodwin—Another portion of the paper cannot be too clearly understood; that is, that the splits, or divisions of air, have less effect if divided some distance from the shaft. I have conducted many experiments, but I have always found that the effect is much greater if they can be taken direct out of the shaft.

Mr. J. J. Atkinson—No doubt of it. The benefit of splitting air depends in a great measure upon the proportion of resistance that occurs in the shafts as compared with that which occurs in the workings. The total pressure applied may be divided into two separate items, one of which is employed to overcome the shaft friction, and the other to overcome the resistance in the workings. Generally speaking, you can subdivide the workings till you reduce the friction very materially; but the friction in the shaft is of course always the same for a given quantity of air, and it is only from reducing the friction in the workings, that the beneficial results of splitting the air are derived.

The President—In directing attention to this point, do not let us lose sight of the fact that Mr. Atkinson has given a caution with

regard to the return air, that where the return air has to go over the furnace, always let the different splits of return air get well mixed before reaching the furnace; so that if any one split is foul it will be diluted before reaching the furnace.

Mr. Goodwin—I think all managers should have a sufficient knowledge of what air is; and if anyone is not sufficiently conversant in these matters as to say whether the air is pure enough or not to pass over the furnace, he is not fit for his position.

The President—But there are such things as a fall of roof, driving gas out of a goaf, and gas suddenly issuing from some part of the strata, so as to foul the air.

Mr. Goodwin—I fear we are now drifting unto a much vexed question.

The President—No; it is mentioned in the paper, and it bears very closely upon this point of splitting. Mr. Atkinson recommends you to split the air as near the downcast shaft as you can; and also to take care and provide against any one split coming to the furnace in a foul state, by having room for mixing before you bring them to the furnace.

Mr. Goodwin—But some of their advantages will be neutralized if you mix the return air of the splits at a considerable distance from the furnace, and thus render it necessary to increase the velocity of the main return current of the air.

Mr. J. J. Atkinson—No doubt; but you must either have that to some extent, or in certain cases incur danger.

The President—But this mixing passage as we call it must be large enough to bring the friction down to the requisite amount.

Mr. Goodwin—The paper is of such a voluminous character that it is impossible to pick out all the points of interest without longer time for consideration.

The President said that this paper, as well as the preceding one by Mr. Atkinson, and the other papers could be purchased at Messrs. Thomson and Baxter's, booksellers and printers, 40, Princess Street, the printers of the Society's Transactions.

Mr. Peter Higson—I think there is sufficient material in the paper to furnish discussion at a future meeting.

The President—I think there is material there for reflection and reference for years to come. Mr. Atkinson is one of the few who is really capable of higher flight than this, and has treated on some of the more intricate subjects of ventilation; still this is a very valuable treatise. I shall be happy to have it to discuss at a future meeting.

Mr. Atkinson (Hon. Sec.) suggested that it would be useful to have the experience of miners contrasted with the principles that Mr. Atkinson has laid down.

The President—I think the true principles of ventilation are far too little understood. It is principally by the "rule of thumb" that the increase and decrease are made.

Mr. J. J. Atkinson said he had endeavoured to render his paper as simple and intelligible as possible.

In reply to Mr. E. Hull,

Mr. J. J. Atkinson said that to get the best results from a given quantity of coals the furnace should be as near as possible to the upcast shaft.

Mr. Hull—But in case an explosion does occur, originating with the ventilating furnace, there should be an easy passage from the mine, through which the explosive gas can go. I recollect the President, when explaining the nature of the accident in the Hetton Colliery, showed that the furnace was situated at a very considerable distance from the bottom of the upcast shaft, and that it was the propulsion of the explosive gas in going towards the upcast shaft which knocked down a ventilating crossing that passed over the main intake air-way, allowing the gas to communicate with the works of the mine, and thus caused the damage that was committed; and it struck me, at the time, if the furnace had been situated at the bottom of the shaft, instead of at a distance, such an accident could not have occurred; for if an explosion had taken place it would have been sent up the upcast shaft at once.

Mr. J. J. Atkinson—But that explosion occurred at an engine fire: it was not a ventilating furnace; and of course the engine was placed where it would do its work best.

The President—There was also a ventilating furnace which was nearer the bottom of the shaft. The drift from the boiler fire joined the furnace drift at the bottom of an inclined plane before reaching the upcast shaft.

Mr. A. Knowles—I have not heard you allude, Mr. Atkinson, in your paper, to the use of dumb drifts, in connection with the ventilation of collieries. Do you think they will be requisite?

Mr. J. J. Atkinson said that in some collieries, where discharges of gas occurred, it might be expedient to use dumb drifts; but he would rather have sweeping ventilation, as a rule, and a mixing of the return air from the place where the gas was given off with that from the other ways, so as to render it safe before reaching the furnace

The President—You must be careful to have sufficient mixing room before letting the air come on the furnace.

Mr. G. Charlton—Would it not be desirable as a rule to supply the furnace with pure air?

Mr. J. J. Atkinson—If you supply the furnace with fresh air, you can never get with the same furnace the same amount of air into the workings, and our object is to cut down the amount of friction in the downcast and upcast shafts. There is one rare case where that does not hold, and that is if your returns were so charged with carbonic gas, so fearfully charged with it, that they would not let the furnace burn, you would have nothing else for it but to use fresh air, but you would use it at the expense of not getting the same amount of ventilation as you would get with ordinary air.

Mr. G. Charlton—Are there not some official records of the effect of supplying furnaces with fresh air in the Wigan district?

The President—Yes; and they bear out what Mr. Atkinson has said, that the largest amount of air is got when the furnace is supplied with the return air.

Mr. A. Knowles—Is it possible for the returns to be so charged with gas as in the roof to be at the explosive point, and yet to cross the ordinary furnace without being fired?

Mr. J. J. Atkinson—I should say not, except under most extraordinary circumstances. If you had a blower within 10 yards of the furnace, and that blower was in the roof, even in such a case as that, I think that it would be a barely possible, but most improbable thing, that it might be at the explosive point at the top and not explode at the bottom, and so pass the furnace without giving rise to an explosion.

The President—Particularly so; when you consider that in the most efficient furnace ventilation, the passage through the furnace should be the smallest space, where the air has to pass; but it is said there have been cases where the air has been almost entirely at the explosive point, and yet the velocity of the air through the furnace has been so great as to prevent it firing back into the current.

Mr. A. Knowles—Suppose you had five return currents, and one of them was at the explosive point, would it be possible for that current to explode before it could mix with the other four?

Mr. J. J. Atkinson—If it was carried only a few yards after mixing with the other currents, and before reaching the furnace, it is just within the range of possibility that such a thing might occur, but it is altogether unlikely to happen.

The President—The current should have a greater run than 10 yards for mixing.

Mr. Goodwin—I think experiments have shown that they would explode like gunpowder.

Mr. J. J. Atkinson—I think Mr. Wood and the late Mr. Stephenson made some experiments, and found that by increasing the velocity of

the current the gas would not go back and explode; but that if they lessened the velocity it would go back and explode. There is something in the velocity, but in a large air-way with a low velocity of air such as we have in mines, there is no likelihood of an explosive current being prevented from exploding from such a cause as that.

The President—I think that was the principle upon which the late Mr. George Stephenson formed his safety-lamp.

T. T. Wilkinson, Esq., F.R.A.S., communicated the following note, which was read by Mr. Atkinson, (Hon. Sec.):

On the Discharge of Air through Uniform Passages or Tubes.

In Mr. Goodwin's paper "On the Ventilation of Mines," he appears to doubt the truth of the laws laid down by authors, which regulate "the friction of air," and on the "quantity passing through a given pipe or passage, in a given time." When the requisite precautions are taken, I cannot find that there is any good reason for doubt on this point.

As this problem is of much importance in the ventilation of mines, it may be well to give in a few words the recognised theory on the passage of air through pipes, &c.—it being premised that in all calculations of this kind, the surfaces of the air-passages are supposed to be

free from angular obstructions, and of uniform contour throughout. When such is not the case, the *theoretical* will differ considerably from the *practical* results.

It is proved by writers on hydrodynamics that air flowing through an aperture, or a tube, follows the same laws as water, or any other fluid. Hence putting v = velocity of discharge in feet per second; l = length of pipe, or passage; d = its diameter; g = force of gravity; and k = a constant to be determined by experiment; also h = height of a column of air equivalent to the resistance of friction; we have

$$h = \frac{klv^2}{dg^2} \quad - - - - - \quad (1).$$

It is therefore evident that the resistance of friction in pipes, or passages, is directly as their lengths, and inversely as their diameters, when the velocity is constant. It is also directly as "*the square of the velocity*" when the lengths and diameters are constant. This agrees with what Mr. Goodwin states on page 174 of the *Memoirs*, and is also in accordance with Downing's *Hydraulics*, or Neville's *Formalæ*, p.p. 103, 137. From a well-conducted series of experiments, Poncelet found $k = \cdot 028$ nearly; and Downing states that "experimenters have shown that equation (1) gives the resistance a *very little* too high."

From a large number of experiments Bossut inferred, and his conclusions have been confirmed by other inquirers, that "the quantities discharged" through tubes, or passages, "in given times," when all other things are constant, "are proportional to the squares of the diameters," or other similar dimensions; and further, that "when the diameters, &c., are equal the discharges are *inversely* proportional to the square roots of the lengths." Hence, if Q and Q^1 be the quantities

discharged; t = the time; v = the constant velocity; d and d_1 = the dimensions of the passages; L and l = their lengths; we have

$$Q : Q^1 :: d^2 : d_1^2, \quad - - - - - \quad (2).$$

Also,

$$Q : Q^1 :: \frac{1}{\sqrt{L}} : \frac{1}{\sqrt{l}};$$

whence

$$Q : Q^1 :: \sqrt{l} : \sqrt{L} \quad - - - \quad (3).$$

From equation (3) we infer that the longer the pipe, or passage, the *less* will be the discharge, and hence Mr. Goodwin's rule ought to have said "*inversely proportional* to the square roots of their lengths."—(*Memoirs, p.p.* 175). As, however, he is correct in his numerical illustration of the rule, the mis-statement of it here pointed out seems to be the result of a mis-print or of an oversight, and does not vitiate his argument.

The President thought that the reading of this paper might take Mr. Goodwin a little by surprise; and it would perhaps have been better that the purport of it should have been communicated to him. Mr. Goodwin's statement of the theory, leaving out of view the error in the report, was correct; but his objection to it was that it did not agree with the results found in practice in the ventilation of mines.

Mr. Goodwin said he had no objection to the paper being printed, though the better way of dealing with the error, now pointed out, would have been to have communicated with him by letter on the subject. He did not just then recollect every particular he had stated in his paper alluded to, but he could say with confidence that

on no occasion had he found two experiments on the passage of air through mines, however carefully conducted, give results that were alike, much less in agreement with the results required by the theory.

The President—It is exceedingly difficult to measure with accuracy the quantity of air flowing through the air-ways of a mine.

The meeting then terminated.

ERRATA.

Page 228—2 lines from the top; *for* "eight parts" *read* "eight and one half parts."

Page 228—6 lines from the bottom; *for* "71·726" *read* "78·726."

Page 230—4 lines from the top; *for* "New Cottle" *read* "Newbottle."

Page 234—6 lines from the bottom; *for* "no two material bodies" *read* "no other material body."

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 13.] [Session 1861-62.

ORDINARY MEETING, *Tuesday, April 29th*, 1862.

JOSEPH DICKINSON, ESQ., F.G.S., President, in the Chair.

The President stated that the Council thought it desirable to make an excursion on the 7th of May to examine the rocks in the neighbourhood of Dulesgate and Gauxholme, where some very fine sections of the lower coal-measures might be seen. It was proposed to go to Todmorden, and return in the evening by train. The suggestion met with the concurrence of the members present.

SAFETY-LAMPS.

The President—Here is a safety-lamp, made and exhibited by Mr. J. Scott Withnall, of Manchester; there is nothing novel in it, except the mode of fixing the lock to the solid bottom of the lamp.

Mr. Withnall—The lock is put in there for the purpose of securing the lamp. With screws alone, a lamp is easily unfastened.

Mr. J. Atkinson—Of course, if a man had a key, he could open the lamp?

Mr. Withnall—Yes.

Mr. J. Atkinson—Messrs. Jones & Charlton have a lamp that has been exhibited here, which cannot be unlocked without putting out the light.

Mr. Withnall—I don't know whether I have seen the lamp to which you refer; but I have seen one of the same description which can be undone without extinguishing the light.

Mr. G. Charlton—Ours cannot be undone without putting out the light. It has never been so undone yet by anyone, and I don't think it can be done.

The President—The novelty of Mr. Withnall's lamp is that the lock is *fixed* in the bottom of the lamp itself. There is one thing, however, which is not sufficiently attended to in the locks for safety-lamps, and that is, that they are all made to lock opposite a particular mark. Now, when the lamp comes to be used, the screws wear a little, until the bolt of the lock will pass the hole intended for it. It should be made to lock all round, when screwed tight.

Mr. Withnall—That can be easily remedied by making several holes for the bolt, instead of one.

Mr. Binney—This is all very well as to the lock; but the reason why colliers unlock their lamps, is, that they want more light. I am surprised to see this awkward old pricker still used. Every new lamp has this old pricker. Surely there might be some more convenient mode of raising and lowering the wick and of extinguish-

ing the light. I would suggest that the lamp-makers should make a kind of rack, by which the wick could be drawn up or down as in other lamps. The aim should be to get as good a light as possible with the quickest means of putting it out in case of danger.

Mr. Farrimond—(handing another lamp to the President) This is another lamp that is self-locking, and you cannot undo it without putting the light out.

The President—This is on the same principle as both Waring's and Jones & Charlton's.

Mr. Farrimond—It is self-locking as well.

Several lamps were mentioned in the course of a conversation which followed.

The President said he thought the Museler lamp was the best. It was generally used in the mines in Belgium, and was self-extinguishing in fire-damp. It possessed all the qualities of a good lamp, but there was such an objection in England to all glass lamps, that it could not be got into use.

Mr. Binney—I think there is an objection to glass without gauze.

The President—If you have the gauze you lose the good light. For *testing*, the Davy lamp seems the best, but for working the Museler is the best.

Mr. Withnall—We can make a lamp which nobody can unlock, provided the masters will pay for it, but they won't.

The President—Chubb's locks would meet all that.

Mr. Withnall—But they won't pay the price.

The President—You must bear this in mind, that a lucifer match sets the opening of the lamp aside.

Mr. John Taylor, jun., read the following paper—

On the Geology of the Railway between Hyde and Marple.

Several journeys over the above railway for the purpose of noticing the general features of the beds through which it passes, and the interest which was created in my own mind by them, have induced me to submit to your notice the following remarks. I do not wish it to be understood that this paper will contain a full exposition of the geology of the district; as this is not required, therefore, I simply lay before you such points as took my attention and engaged my interest.

The length of the line, through which the cuttings have been made, is about seven miles; although I understand that it is intended to be extended from Marple to New Mills, when, doubtless many other subjects of geological interest will reward the attention of the careful observer. Fortunately, for observing the sections exposed along the railway—which, in some places are as much as 60 feet in depth,—it trends in a direction nearly coincident with the line of strike of the rock; so that it affords a very favourable opportunity for observing, for the distance of several miles, the changes which occur in the distribution of the fossil remains. This circumstance enables one to perform that interesting pursuit with the greatest ease, instead of having to journey many a weary mile over tracts covered up by over-lying drift to glean such information from sections exposed along river-beds, or obtained from the sinkings of coal-shafts. The country through which the

railway passes, undulates very much; so that, though in several places there are cuttings of from 20 to 60 feet in depth, in others the line crosses valleys at a height of more than a 100 feet. These numerous valleys have all been formed by denudation, or the wearing away of the under-lying rocks, subsequent to their deposition, and, very probably, at the close of the pleistocene age, when the land, covered up with its burden of drift was slowly rising from the sea; for the drift-beds are chiefly found capping the summits of these mounds—alluvium occupying the valleys.

The geology of the railway may at once be set down as belonging to two widely separated formations, the lower coal-measures and the pleistocene. I purpose, first of all, to draw your attention to the former.

In going along the line from Hyde, we find the under-lying rock coming up about two miles from that town. It first appears for a few yards as a thin-bedded, argillaceous sand-stone, over-lying beds of shale. No organic remains are found in it, but the shales beneath teem with myriads of *Anthracosia*. These shales are exceedingly fine and thinly laminated, and do not present the appearance which the ordinary shales over the roofs of coal-seams do, being neither so argillaceous, nor so much disposed to break into shapeless fragments, for the masses have a disposition to be shattered into cubic or rhombic forms. The dip is on the right-hand side, in a direction nearly north-west, and at an angle of ten or fifteen degrees. Iron-stone bands, several inches in thickness, frequently alternate with the shales; and along the whole length of the line, these beds are not lost sight of. As we approach Marple they seem to have been affected by dislocations; and, about a quarter of a mile beyond the aqueduct, a fault is seen in the section—a down-throw of several feet. Near Romily the gullets are deeper, and these shale-beds are succeeded by thin flag-stones, most decidedly ripple-marked. The surface of one

was exposed, *in situ*, over an area of many square yards, and I could distinctly trace ripple after ripple as they had left their impressions when these flag-stones were plastic to their influence. Over these beds lie masses of sand-stone rock, of rather a coarser texture, and containing imperfect impressions of *Calamites* and *Sigillaria*. Some two miles farther this rock is succeeded by one of a conglomerate character, and very hard—the matrix being of a light grey colour, and the imbedded pebbles quite red. With the exception of these over-lying rocks, the shale-beds occupy the main features of the geology of the line.

In the places nearest to Hyde, where the shales are first exposed to view, they are found to contain fragments of *Lepidodendra* and *Neuropteris;* and, with these plants are associated great numbers of the coiled tubes of the annelid *Spirorbis carbonarius*, along with minute entomostracan *Cyprids*. Many of the *Spirorbi* are pyritized, and are of so large a size as to induce me, at first sight, to believe them to be small Goniatites. The fossils are found in the company of several species of *Anthracosia*, and the whole are so commingled as to shew that they shared a common habitat. The *Anthracosia* found in the iron-stone band are the more interesting to the palaeontologist, from the fact that numbers of them are met with shewing the interior of the valves, and consequently exposing the hinge—a feature which is valuable in the present state of knowledge upon this subject, and which may do much towards settling the various opinions upon the habits of the animals. Many of the latter fossils lie imbedded perpendicularly to the lamination of the shales, in the manner that Mr. Salter has shewn to be the habit of the recent *Mya*, when alive in its muddy home.

In tracing these apparent fresh-water shales towards Marple, we find the imbedded fossils changing to decidedly *marine* ones, such as *Goniatites, Aviculo-pectens,* etc.—these being also mixed up

with *Anthracosia*. There are, I believe, several instances on record of shale-beds changing in the nature of their fossil remains; among them, if I remember right, is an instance cited by Mr. Binney, of the *Unio*, or *Anthracosia* shale-bed at Whaley Bridge yielding *Goniatites*, &c., at Froghall, in Staffordshire. This peculiarity of the Marple shales, therefore, is another instance to be added to the rest. I may just say, that the only difference in the mineral character of the shales at the Marple end from those at Hyde, is, that the former have more metallic lustre, and are not quite so finely laminated.

The fact I have just mentioned is another proof to me that the hitherto so-called fresh-water *Unio*, or *Anthracosia*, was, in reality a *marine* shell, which lived in the shallow and brackish waters of the sea; and that the shale-beds already described are but its consolidated beds, shewing as we walk over them, not only the variations in its depth but also the different creatures, which, in consequence, inhabited the various waters. The nearest living representative of the fossil *Anthracosia*, the *Myas*, according to Mr. Woodward, "frequent soft bottoms, especially the sandy mud of the river-mouths, where they range from low-water to twenty-five fathoms in depth." And it was in these deeper waters that the cephalopodous molluscs of the *Goniatite* genus lived—true to the character of the family as exemplified in the present day. Again, that *Anthracosiæ* were not *fresh-water* mussels is indicated by the fact that neither they nor their marine namesakes burrow in the mud,* but usually attach themselves to stony places. Fresh-water mussels are usually found clinging to the stony sides of canals, or to the rocky beds of rivers. Those in the sea, in like manner, adhere to the sides of ramparts, and also to the rocky bottom of the ocean. Both these varieties are provided with a *byssus* to enable them to anchor themselves in this manner. But the fossil mussels found in these finely laminated shales must have

* Are they not sometimes found in muddy ponds?—Ed.

been littoral mud-burrowers, for there was no rock in the neighbourhood of the waters in which they lived to which they could have anchored themselves, whilst every layer of shale is covered with myriads of individuals. These and other considerations, lead me to the conclusion already arrived at by Mr. Binney, Mr. Salter and others, that the genus *Anthracosia* of our coal-shales was related, not to the *Unio* of our streams and ponds, but to the mud-loving *Myadea* of a brackish sea.

The drift deposits which overlie the beds above-mentioned, are much of the same character with those found in other localities. We do not meet with much Till, however, until we have crossed the aqueduct at Marple, when these beds are seen containing huge boulders of porphyry, granite, syenite, etc.—the boulders being generally rounded, and the larger ones scratched and striated. About a couple of miles from Hyde, in a section where the drift deposits are cut through to a depth of about 30 feet, they consist of beds of sand and clay, alternating with each other, and, in these beds, for the distance of about a hundred yards, I have met with fragments of marine shells, of the genera *Tellina*, *Cardium edule*, *Turritella terebra*, and *Astarte*. They are all in a more or less fragmentary condition, but several good hinges and portions of the valve were sufficiently distinct to enable me to determine the genera and species. Now, I have walked over the ground from this place to the fossiliferous sands on the Stockport and Woodley line, described by me in a former paper, and have come to the conclusion that these shell-bearing sands and clays near Hyde are but a continuation of them. The genus *Astarte*, however, I did not find represented in the Stockport series; and it is certainly singular, that although I walked over and carefully searched the drift beds for several miles further on, I could not meet with pleistocene fossils, except in this single locality.

Owing to these alternating beds of sand and clay, great incon-

venience is caused to the engineer in giving a finish to the appearance of the gullet sides, from the water flowing out at the junction of the sand and clay, and carrying down with it a portion of the former. This circumstance has been injurious to the Stockport and Woodley railway in a similar manner. A cheap and ingenious device, however, has been resorted to near Hyde, in order to overcome it. In those parts where the banks are most moist, tolerably deep troughs have been dug in them—these troughs are afterwards filled up with fragments of stone, so as to serve not only as buttresses to strengthen the embankment, but also as natural drains for the water to trickle down into the channel below. I should have observed before, that exceedingly rich beds of calcareras marl, sometimes several feet in thickness, are seen capping the drift deposits in many places; and, in one or two instances I fancied that I could detect the remains of shells.

In closing, I cannot but remark the part which each of these widely-separated formations fulfilled; and, whether the first mentioned deposits, subsequent to their consolidation, existed as dry land whilst the southern part of England was repeatedly under the sea or not,—we know that in the interval of their being covered up by fresh beds, thousands of feet of solid rock had elsewhere been deposited, and numerous generations of animals and plants had passed away. And, although these two formations are like the abutments of a great arch, separated by a span of countless ages, yet their unity of design may be clearly traced, for, while the vegetation of the one was quietly and safely stowed away as coal—in the other was elaborated a sub-soil that should serve as "mother earth" to the lately created flora of the human epoch.

On the motion of Mr. J. Atkinson, seconded by Mr. Binney, the thanks of the meeting were given to Mr. Taylor for his paper.

Mr. Binney—I should like to ask a question as to the position of this bed of bi-valve shells,—whether Mr. Taylor considers them below the Lower Woodley Mines or above them?

Mr. Taylor—At first I thought the position was above them; but, after going over the ground very carefully, I believe the shells are below.

Mr. Binney—When we go from Marple Bridge across Romily, we seem to go over a good deal of the lower coal-field. I have seen gannister coal at Romily; as we get further up the hill to Werneth Low, we find rough rock.

Mr. Taylor—I have not been able to determine the place.

Mr. Binney—Is it a bed in the lower coal-field, or immediately below a part of the middle of the Woodley coal?

Mr. Taylor—I rather think it is below the Woodley coal.

Mr. Goodwin—I cannot but come to the conclusion that they are at least 100 yards below the Lower Woodley Mine.

Mr. Binney—The Lower Woodley Mine, I take it, is the representative of the Arley Mine.

Mr. Goodwin—Just so.

Mr. Binney—I should not take Lepidodendron or Sigillaria as indicating the position of the strata. When I was a young geologist, I read in books that the occurrence of particular plants in a bed might point out the exact position of a seam of coal. I soon, however, began to doubt the value of common coal plants in identifying strata to the extent claimed for them. Probably the *Anthracosia robusta* is considered by practical colliers as the most valuable guide in sinking down to the Arley Mine.

Mr. E. Hull—Below Eagley Bank, in the measures overlying the gannister seams, most capital specimens of this very shell have been found and determined by Mr. Salter; and there is another one of very similar appearance which comes far below that, in Scotland; so that the *Anthracosia robusta* can no longer be considered as distinctive of the beds overlying the Arley Mine.

The President—The "mush-bed" overlying the Little Delf at St. Helens is identical with the shell-bed that overlies the Little Delf, or Arley Mine, at Wigan.

Mr. Binney—I say that organic remains are not always to be relied upon. Organic remains must be taken with a little allowance; they may be noted, but I don't think we ought to decide exactly by them. I have examined personally some of the mines in Ayrshire, and have found the large *Anthracosia* in the blackband common. With regard to these drift-beds, which Mr. Taylor has mentioned, I am glad to hear that he had found shells in another locality. The shells that he has described seem very similar to those that have been found in the valley of the Etherow, as high as Tintwistle. Those which he has discovered in the neighbourhood of Stockport, and those named to-day, show us that the fossils we find near Blackrod, Tyldesley, Haigh, and Bowdon, have a large range; and even in Staffordshire, I think, we should find them as well. The drift deposits get far more complicated on the sides of hills. Where we are, in Manchester, we have a pretty clear bed of Till or brick clay, and sand gravel over it, on the top; but when we get on the hill sides, we find them split and divided a good deal.

The President—Some years ago, it was a qualification for membership of the Institute of Civil Engineers, that young engineers should make geological sections of the cuttings of railways. Have you kept any record of the cuttings you refer to in this paper, Mr. Taylor?

Mr. Taylor—I have sections of them all, and I should be happy to append them to the paper.

Mr. Binney—We can do with such sections in our Museum.

Mr. Taylor—I may just state that in these coal-shales I came on *Anthracosiæ*; and, returning on Good Friday, I showed them to Mr. Charlton. Some of them are as large as the *robusta* I have seen above the Arley Mine.

The President mentioned that in the Agecroft Colliery some shells had been found lying above the Black and White coal-seams.

Mr. John Knowles said he had the sections of the mines, but did not know that shells had been found.

Mr. John Bradbury, jun. read the following remarks upon

THE NORTH STAFFORDSHIRE COAL-FIELD.

Mr. President and gentlemen—In appearing before you on this occasion, permit me to observe, that the subject under consideration is one that I feel my inability to do justice to; and even were I capable of doing justice to the subject, it would be difficult to group all the points of interest to be found in this singularly rich, and highly interesting coal-field into the limits of one paper.

My apology for bringing this subject before you, is a desire to give the Society all the reliable information that I am enabled to do, concerning the peculiar position in which coal and the accompanying strata are to be found in some parts of the North Staffordshire coal-field. From the high scientific and practical attainments of some of the members of this Society, it is to be

hoped that the Society will be benefited in a geological point of view from the discussion following the reading of this paper; and that some of the members of this Society may be induced to give a full and detailed description of the subject which I so imperfectly bring before your notice. In consequence of the upper series of mines being unproductive in North Staffordshire, and so far as I am aware, not workable in any case, the same opportunity has not presented itself for making observations as otherwise would have done. I shall therefore content myself with stating upon the authority of Mr. Hull, F.G.S.,* that the thickness of the permian strata and the new red sandstone, down to the middle series of coal-measures is 1600 feet. The vertical section that I have prepared, is from the actual distances between the respective mines, and the thickness of each of the mines as found under ordinary circumstances. The remarks upon the contortions and peculiarities of this coal-field, are bearing more particularly upon the district between Golden Hill and Biddulph.

The North Staffordshire coal-field is irregular in form, but somewhat approaching the form of a triangle; it is of very limited area, not exceeding 76 square miles. A line drawn through the centre of the coal-field, from Hartwell to Biddulph would be about 12 miles, this is the greatest distance between any two points, excepting the Cheadle coal-field is also included; then, the width would be about 15 miles. The number and richness of the workable seams of coal, and ironstone, however, somewhat compensate for its limited area, and place it in a favourable position when compared with others of greater area. At present it is only partially developed. It contains thirty-nine workable seams of coal, varying in thickness from 11 feet down to 12 inches. When coal-seams are worked in connection with ironstone, they are sometimes worked of the latter thickness; but, in computing the number of workable seams, I have not taken into account any

* The Coal-fields of Great Britain, by Mr. E. Hull, B.A., F.G.S., 1861.—Page 95.

below 2 feet in thickness, unless those that are, and have been worked. It is probable that at no very distant period, some of the thin seams now considered unworkable may be worked to advantage, from the fact of being associated with beds of ironstone or fire-clay. The number of workable seams of ironstone is twelve, varying in thickness from 9 inches to 7 feet and upwards.

The Red Shagg is the only seam of ironstone in this district, so far as I am aware, that has ever been found more than 5 feet in thickness, and it is only in exceptional cases that the Red Shagg exceeds that thickness; it has, however, been worked both in the neighbourhood of Tunstall and at the White Barn Colliery, near Newcastle, of greater thickness than that named. The aggregate thickness of the workable seams of coal in this coal-field, exceeds 156 feet, and that of the workable seams of ironstone 26 feet 6 inches. I have not taken into account the thickness of a seam of coal and ironstone where it has been more than an average thickness; but have aimed at being rather below the average. It is probable that improvements may be made in the smelting of iron, ere long, that will enable the iron manufacturers to use much of the poorer ironstone of this district, that is now thrown away or wasted in working. The Cheadle district, which may be considered a detached portion of the same coal-field, will not, on the present occasion, be brought before your notice, inasmuch as I am not sufficiently acquainted with the district to lay before you information of a reliable character.

The new red sandstone and permian strata form the boundary of a considerable portion of this coal-field. Its limits and the surrounding formations are shown on the maps of the Geological Survey of Great Britain. If we assume the figure of it to be a triangle and trace its boundary from Mow Cop, which may be considered its apex, we shall have on the north-western side the new red sandstone, which extends as far as Audley:

at which point, the permian strata commence, and run along the remaining distance of that side of the triangle, and across its base, until it is again joined by the new red sandstone at Cocknage Hill, Blurton, which extends as far as Brookhouse Farm, near Wetley. The remaining portion of the boundary from Brookhouse to Mow Cop is of millstone grit. In the neighbourhood of Mow Cop, the millstone grit is probably better adapted for the manufacturing of millstones than in any other part of the county. This trade appears to have been carried on in this locality almost from time immemorial, as several of the quarries bear unmistakable traces of having been worked for such purpose before the use of powder was known, or even the primitive system of using lime for the blasting of rocks.

If the surrounding country be viewed from the summit of Mow Cop, it will be easy to see that some immeasurable force has raised and contorted these rocks since they were deposited in their original position. The deposit now forming Congleton Moss, lies at the foot of the opening of this range of hills; it contains much timber, which is found lying almost in every direction, and buried a considerable depth; some of the trees are found with the soil in which they once grew still adhering to the roots. It appears as though the timber found buried in this moss had been washed from the higher grounds, upon which it had grown, by some mighty torrent that had carried away all before it.

I believe it to be the general opinion, and one with which I agree, that the coal-measures are to be found under the permain and new red sandstone rocks; if so, it is possible that by the aid of improved machinery, &c., connected with the workings of mines, and more science being brought to bear upon the management of them, that a great area will be added to this coal-field. Perhaps the time may be far distant, but its possibility, I think, can scarcely be doubted.

The Blackband Ironstone is the highest mine in position, in the middle series of mines, and of more than an average quality; it is worked at several of the collieries in the neighbourhood of Tunstall, and also at Fenton Park, Silverdale, near Newcastle, and other places in the same coal-field. I fear it would occupy too much of your time were I to offer remarks upon each seam of coal and ironstone, I shall therefore confine my remarks to those that call for special attention.

The Red Shagg and Red Mine Ironstones are both the richest and the cheapest to work of any in the whole series. The thickest coal seam is the Rowhurst; this coal is also of very good quality, and principally used for domestic purposes.

The Birchenwood Coal is highly valued both for domestic purposes and for the burning of earthenware; it is both a very clean burning and capable of producing an extraordinary amount of heat.

The Bowling Alley is a very strong coal, and very similar to the splint coal of Scotland; it was long considered to be unsuited for the manufacturing of pig iron; however, recent experiments have proved that this seam, as found in Biddulph, is admirably adapted for such purpose, and is now extensively used by R. Heath, Esq., and others in the manufacturing of pig iron; it is also one of the best coals for locomotive purposes in the district; this seam often reposes upon a very strong rock, without the slightest appearance of anything like fire-clay.

The Two Bamburys, known by the different names of 7 feet and 8 feet Bamburys, the Frogrow, New Pool, and other local names, are extensively used for coking in some parts of the coal-field, and both are of good quality for domestic purposes.

The Holly Lane is the best house-fire coal in this district, but free burning.

The Bullhurst coal is very irregular. Its true position should be two seams of 3 feet each, separated by a seam of soft dirt 4 inches in thickness; but it often happens that the top coal is altogether absent, or only 9 or 10 inches in thickness; the change takes place without any fault intervening, or the quality of the lower seam being impaired.

The Winpenny Coal—a seam about 3 feet in thickness, reposes upon a bed of ironstone, containing a considerable quantity of siliceous matter, and possessing the property of smelting at a very low temperature.

The Silver Mine coal is the lowest workable seam in the middle series; there is, however, another mine about 2 feet in thickness at 52 yards below the Silver Mine. The distance between the lowest mines in the middle series, and the uppermost in the lower series is 143 yards.

The Four-Foot Mine is the principal mine in the lower series. It is worked at Biddulph; and is there known by the name of the Crab Tree; it is a good coking coal, and well adapted for the manufacturing of iron in some of its stages. It was long thought by some of the pig-iron manufacturers, that none of the coal in the North Staffordshire coal-field was well adapted for manufacturing pig-iron; to such an extent was this feeling carried against the local coal, that some of the largest pig-iron manufacturers in the district purchased their coal from Derbyshire and other places, although themselves working coals that have since been proved to be of excellent quality for this purpose.

The Bowling Alley, Stony "Eight-Foot," and Rough "Seven-Foot"

Mines are now acknowledged to be choice coals for the blast furnaces; some of the other seams are also used for the same purpose.

Until the opening of the Biddulph Valley Railway, most of the coal of this district was used in the neighbourhood of the Potteries, for the manufacturing of earthenware and iron, in all their branches; since which time, facilities have been afforded for both bringing more coal into the market and for securing a greater demand.

I will next read over an account of the general thicknesses of the seams of coal and ironstone, with the distances between each; first remarking that its general correctness may be relied upon, although it may be found to differ from some of those already published. Perhaps the difference may have been occasioned by the sections being taken from different parts of the same coal-field.

	Thickness.		
	Yds.	*Ft.*	*In.*
Blackband Ironstone	0	1	6
Strong Bass	14	0	0
Red Shagg Ironstone 4 feet do. Coal 1 foot 9 in.	1	2	9
Rock, Binds, and Bass	24	0	6
Red Mine Ironstone 2 ft. 9 in. do. Coal 2 ft.	1	1	9
Metal, Coal, and Bass	10	1	6
Coal	0	1	8
Rock, Binds, Coal and Bass	19	0	0
Coal	0	1	0
Rock, Linsey, and Bass	25	0	6
Coal	0	1	0
Warrant, Rock and Strong Metal	21	0	0
Bassey Mine Ironstone 4 ft. do. Coal 1 ft. 6 in.	1	2	6
Little Row Coal	0	2	6
Peacock Coal	1	1	3
Linsey	14	0	0
Spencroft Coal	1	0	6
Warrant and Light Metal	18	0	6

	Thickness.		
	Yds.	*Ft.*	*In.*
Gubbin Ironstone in Bands	1	2	0
Rock, Binds	11	0	0
Great Row Coal	1	2	0
Rock, Linsey, Metal, and Bass	28	0	0
Cannel Row Coal	2	0	0
Warrant, Coal, Metal, and Bass	29	0	6
Wood Mine Coal	0	1	3
Pennystone Ironstone	0	2	0
Deep Mine Ironstone 2 ft. do. Coal 2 ft. 9 in.	1	1	9
Metal, Linsey, and Bass	24	1	0
Chalkey Mine Ironstone 1 ft. 6 in., Coal 1 ft. 6 in.	1	0	0
Brown Mine Ironstone 9 in. do. Coal 1 ft.	0	1	9
Warrant, Coal, and Bands of Ironstone	18	1	0
Bungilow Coal	0	2	6
Rock and Strong Blue Metal	38	0	0
Coal	0	1	0
Warrant, Linsey and Bass	34	0	0
Little Coal	0	2	0
Winghay Coal	1	2	0
Strong Metal and Bass	12	0	0
Rusty Mine Ironstone	0	1	6
Blue Metal, Bands of Ironstone and Bass	40	1	0
Billy Mine Ironstone 6 in. Coal 1 ft. 8 in.	0	2	2
Linsey, Coal and Metal	42	0	0
Coal	0	1	6
Rock, Metal and Bands of Ironstone	10	0	0
Four-Foot Coal	1	0	0
Fire-clay, Bass and Metal	15	0	0
Rowhurst Coal	3	2	0
Light Metal, Rock, Coal and Bass	27	0	0
Bromwood Ironstone 1 ft., Coal 4 ft. 6 in.	1	2	6
Fire-clay, Rock and Metal	17	0	0
Twist Coal and Cannel	1	0	6
Grey Metal and Bass	21	0	6
Coal	0	1	6
Blue Metal, Grey Metal and Bass	29	0	6
Rock, Dark Metal, Grey Rock and Bass	39	0	6
Coal	0	1	0
Metal, Rock and Linsey	31	0	0

	Thickness.		
	Yd.	*Ft.*	*In.*
Linsey, Metal and Black Bass	27	2	0
Birchenwood Coal	1	0	10
Rock, Grey Metal and Bass	20	0	6
Mossfield Coal	0	2	10
Blue Metal	12	0	6
Coal	0	2	0
Rock Binds, Metal and Bass	21	0	6
Coal	0	1	9
Blue Metal, Grey Rock and Bass	45	0	0
Yard Coal	1	0	2
Strong Linsey	11	0	6
Ragman Coal	1	0	10
Metal, Coal, Rock and Bass	25	0	0
Rough Seven-Foot Coal	2	0	6
Warrant, Coal, Metal and Rock	55	0	0
Stony Eight-Foot Coal	2	1	0
Linsey, Grey Rock and Shale	31	1	6
Ten-Foot Coal	2	0	6
Grey Metal and Rock	30	0	0
Sparrow Butts Coal	1	1	0
Strong Metal	15	0	0
Holly Lane Coal	1	2	0
Strong Grey Rock and Metal	55	0	0
Bowling Alley Coal	2	0	0
Warrant, Metal and Rock	15	0	0
Inferior Coal in Three Seams	1	0	3
Metal and Warrant	13	0	0
Inferior Coal in Four Seams	1	0	7
Shale and Black Bass	48	0	0
Ironstone Mine Coal	0	2	8
Grey Metal, Rock and Bass	38	0	0
Frogrow Coal	1	2	0
Strong Rock and Blue Metal	38	0	0
Cockshead Coal	3	0	0
Rock and Ironstone Bonds	31	0	0
Limekiln Coal	0	2	3
Rock Binds, Rock and Strong Metal	48	0	0
Bullhurst Coal	2	0	0
Rock Metal and Bass	20	0	0

	Thickness.		
	Yd.	*Ft.*	*In.*
Winpenny Coal - - - - -	1	0	0
Rock, Bass and Bands of Ironstone - -	61	0	0
Brick-kiln Row Coal - - - -	0	1	6
Shale and Black Bass - - - -	72	0	0
Silver Mine Coal - - - -	1	1	9
Black Bass and Soft Metal - - -	52	0	0
Coal - - - - - -	0	2	0
Strata not known below this point - - -	143	0	0
Coal - - - - - -	0	1	5
Strata - - - - -	47	0	0
Crab Tree Coal - - - - -	1	1	0
Strata - - - - -	14	0	0
Little Row Coal - - - -	0	2	3
Strata - - - - -	74	0	0
Inferior Coal - - - - -	0	1	6

As I have previously remarked, much difference exists in the relative positions of the seams of coal, in a very limited area, for instance, at the Stonetrough Colliery, near Mow Cop, the Sparrow Butts and Holly Lane are so near to each other as to be worked together, forming a mine nearly 10 feet in thickness, known by the name of the Two Row Coal; whilst at the adjoining collieries, Bradley Green, and Childerplay, within two miles of the former the mines are separated by about 15 yards of strata. Nearly all the coal-seams found at Mow Cop and Biddulph are of greater thickness in that locality than elsewhere; they appear to lose their thickness in a gradual or wedgelike form from this point into the centre of the coal-field. From the high angle of inclination of the seams of coal in this locality, the yield per acre, surface measure, is enormous, in some instances exceeding seven times that of a seam of coal of the same thickness of an angle of 12°. I have taken the angle on different occasions and in different collieries as high as 82°. To me it appears difficult to conceive how such coal-seams have been fashioned or formed; for if we accept the prevailing theory that they are of vegetable origin, we need only take into consideration the fact that each seam of coal, if placed

horizontally, would occupy several times its present surface area, in order to become bewildered and lost in amazement in endeavouring to imagine how such a rank and luxuriant vegetation could either have grown upon the spot or have been drifted together. If, on the other hand, we suppose them to have been raised into almost a vertical position by the agency of some mighty power, our finite minds experience the same difficulty in endeavouring to comprehend the cause of the phenomena spoken of. The direction of the rise and dip of the mines in this locality undergoes a gradual change, which is called the "turn again" of the mines; the angle of inclination of the mines also changes. In what are technically called the "rearers" the angle of inclination varies from 40° to 82°, and the line of level or direction of strike is from 48° to 50° S. of W. and N. of E. Upon the flat dip, the angle of inclination varies from 15° to 30°, and the line of level or direction of strike is about 3° from magnetic N. and S. At Cloud End the millstone grit dips in a south-westerly direction. The dip at Congleton Edge is from 40° to 50° S. of E. At a colliery formerly worked to the S. W. of Mow Cop, and at the foot of the hill, the seams of coal dip both N.W. and S.E., or towards Cheshire and Staffordshire.

These changes in the direction of the dip, in some instances, take place with such regularity as to present the appearance of the segment of a circle, as will be seen by reference to the place before you. In other instances, the change is effected by a dislocation or abrupt termination of the coal-seams, in the direction in which they incline. It is sometimes the case, that coal-seams are worked upon both angles of inclination from one and the same shaft; and that the headings or levels form a segment of a circle of about two chains radius, in many instances, the radius would be more than that named. Each seam of coal with its accompanying strata, bears its respective distance to the others, where the change of angle and direction of dip take place; consequently the curve

formed by the "turn again" of the lower or outside mines is of greater radius than the uppermost or inner circle of mines. It is not unusual in this district to find the seams of coal so contorted or moved from their original position as to present the appearance of the same seam being folded together, and presenting two seams, but separated by a few inches of dirt where the roof of the bottom mine should be. It is sometimes the case that three seams are found overlying one another in such a manner that little doubt can be entertained that it is the same seam of coal that has been forced one over the other by some extraordinary pressure or convulsion of the earth; but at what period of time or in what manner it has been accomplished I will not venture to hazard an opinion.

These peculiarities often take place in close contiguity to faults, or dislocations of the strata. Some portions of the coal-field contain numerous faults or dislocations, perhaps none more so than in the neighbourhood of Talk o'th' Hill, although in the neighbourhood of Mow Cop, Harrisehead and Biddulph, the faults are both numerous and of considerable magnitude.

At the Stonetrough Colliery, (Biddulph,) in working the "rearers," five faults are met with on an average of 22 yards each, all downthrows to the S.W. in little over a thousand yards of line of level; whilst at the same colliery, upon the flat dip, a distance of nearly two miles is found without any faults whatever. In Biddulph the faults are also numerous and of every imaginable kind, many appearing to branch out in different directions, from a main fault, in almost as many different forms as the roots from a tree.

Were it not that the seams of coal were numerous, and that a mine either above or below the one removed by dislocation is often brought into nearly the same position as the one removed, it would be questionable whether some of the collieries now worked could

be worked to advantage. In addition to the small faults mentioned, there are several very large ones, one of which forms the boundary of the coal-field near Longton, throwing in the new red sandstone on the east side. In the neighbourhood of Newcastle there is also another fault, a downthrow to the east; it is variously estimated to be from 350 to 400 yards; it passes a little to the east of Hanchurch, whilst another serves to form the boundary or the north-western side of the coal-field; this fault ranges from near Audley to Astbury, near Mow Cop. Assuming the limestone at Astbury to be the carboniferous, this fault is a downthrow to the north-west at Astbury, equal to the whole thickness of the millstone grits and coal-measures, and a considerable portion of the new red sandstone.

A somewhat peculiar circumstance in connection with the faults of this district, is the fact, that at Kidsgrove, Harecastle or any of the collieries S.W. of Harrisehead, most of the coal contains a considerable amount of bitumen, and almost every seam is of good quality for coking. To the N.E. of that point they cease to contain anything like the same amount of bitumen, and the only mine that is at all adapted for making coke is the Crab Tree or Four-Foot mine, in the lower series of mines. So suddenly does the change take place that the coal on one side of a 30 yards fault is remarkably well adapted for coking, whilst on the other side, much money has been spent in the fruitless effort of attempting to manufacture coke.

As stated at the commencement, the points of interest to be found in this coal-field are so numerous that I am compelled to pass over many that might have been briefly touched upon had I not been unwilling to trespass too long upon your time, and thereby lose the opportunity, which I much desire, for hearing an expression of the views of some of those present, who are so much better qualified than myself to explain the cause of some of the phenomena I have attempted to describe.

On the motion of Mr. Binney, seconded by Mr. G. Charlton, the thanks of the meeting were given to Mr. Bradbury for his paper.

Mr. Binney—Some years since, I went to see the North Staffordshire coal-field. Mr. Cope had then published a map of it. This field has been thoroughly sunk through and worked. I found that when I got into the red measures at the top, and the hill coal of the coal-field, Mr. Cope had left them out of his map. I suppose he thought it was quite enough to put down in his map what the colliers had proved. When I was there, I was in company with a very old geologist. We certainly saw coal-measures similar to our Rochdale series. Going up above Norton, we saw gannister coal, and a coal lying underneath it. Also, we saw rough rock at Wetley Moor. We found two beds containing *Aviculo-pecten*, &c. With regard to the upper coal-measures, there is considerable doubt whether Mr. Bradbury has got in all of them in his section. Mr. Sparrow, in driving a tunnel near Lane End, came to a limestone. Then when you come to the neighbourhood of Stoke and Burslem, and get to the top of the measures, I cannot tell where the coal-measures end and the permian beds begin. At Basford and Burslem you get the red clays and pebble beds, and at Basford there is a red sandstone rock containing coal-plants. I don't see the red sandstone put in in this section.

Mr. Bradbury—It does not go high enough.

Mr. Binney—I should like to see some evidence in this section, to show where the coal-measures cease, for I think we shall get higher coal-measures even than our Ardwick ones. I see nothing to prove where the coal-measures go into the permian strata. I never saw a good line of demarcation of these strata, and I could never come to a conclusion as to where the coal-measures ended and the permian began. Some gentlemen afterwards saw a better line of demarcation. Mr. Hull, I think, has put them down in the Geological Survey map; but so far as I went I was puzzled. About Stoke and Burslem I came to the conclusion that I saw nothing but coal-measures.

The President—It is desirable to have a good section of these arranged, so far as we know them. Mr. Bradbury carries them up to the blackband ironstone, but I think they go higher than that.

Mr. Hull, referring to a map which was hanging on the wall, described the situation of the North Staffordshire coal-field. He added that he had always had a high opinion of the richness of the North Staffordshire coal-field, which had been the means of valuable additions to geological knowledge, in consequence of the splendid collections of fossil-fish which had been found in it. Whether they regarded it in connection with its richness in coal, iron, or fossil-fish, there were few coal-fields in England, of the same extent, to be compared with it.

The President said the valuable bed of ironstone in the Churnet valley was the peroxide of iron; but the Red Shaggs at the top part of the section, were true blackband ironstone, and were as good as any he had seen in point of thickness.

In reply to questions, Mr. Hull said he was not aware that he saw any fossil-shells at Adderley Green, near Norton.

Mr. Atkinson—I should like to ask how these "rearer" or highly inclined coals are worked? There must be some peculiarity in the manner of working. It is unusual to have them at so high an angle in this district as is mentioned in the paper.

The President—In North Staffordshire sometimes they are nearly perpendicular. They are worked pretty much in the usual way, Sometimes they have to work them off platforms resting on bars, supported from one side of the seam to the other.

Mr. Goodwin—I believe they drive the levels in the usual way, and erect platforms for the men to stand upon, in entering the works out of the levels, when working the levels back.

The President—Just the same as in the Belgian mines, where the seams are sometimes at a high angle; but they are worked "long work," the same as flat seams, but having platforms to stand upon.

Mr. Andrew Knowles—How is the coal kept from falling on the men?

Mr. Bradbury—We "sprag" the coals.—In reply to a request for an explanation of this term, the President said it meant props and short stumps.

Mr. Goodwin—I should like to hear Mr. Binney express his views upon the Congleton Moss, which is mentioned in the paper. This moss is of great thickness, and, at a considerable depth from the surface, many trees have been found, although the moss is at a high elevation, and at the foot of the opening between two hills.

Mr. Binney—I think that that moss, like nearly all others of a similar character, has originated in the stoppage of the drainage of the country. At the time when it was naturally drained, timber would grow; but if by some cause the drainage was stopped, the trees would soon die in a very wet soil, especially if previously accustomed to a dry one. Probably a south-west wind would blow down the withered trees to the north-east, and these old trees falling amongst the bog plants, would assist in stopping the drainage more; and the stagnation might go on increasing for many years, when a very good moss might be formed. Many of these mosses have been formed since the time of the Romans, because we find Roman urns under them. I don't know the height of the Congleton Moss above the sea level.

Mr. Goodwin—It must be 600 feet above the sea, and there is falling ground all the way.

Mr. Binney—Some stoppage of the drainage must have been the cause of the formation of the moss.

Mr. J. Taylor, jun.—You will find the *Sphagnum* on the steep ground in the Isle of Man, at Kinder Scout, and on many hill sides.

Mr. A. Knowles—Is the South Staffordshire thick coal represented in the North Staffordshire coal-field?

Mr. Hull—I have no doubt it is, but it is in a great number of seams. The thick coal of South Staffordshire splits up, north of Wolverhampton, into many seams, separated by 240 feet of strata.

Mr. A. Knowles—Does the appearance of the coal indicate it as of the same seam or not?

Mr. Binney—This North Staffordshire coal-field is connected with our Lancashire coal-field, no doubt. There would be no more difficulty in identifying its seams with the coals at Dukinfield, than in identifying the Dukinfield coals with those at Wigan.

Mr. Atkinson remarked that in Derbyshire a thick seam of coal is frequently split up into thin seams, within a distance of four or five miles.

Mr. Binney said the coals in Derbyshire had a tendency to unite as they got south.

Mr. Hull said that in tracing the coal strata from this district south into Staffordshire, he had found that the shales and sandstones interstratified between the different seams of coal thin out towards the south. He was not aware that this fact had hitherto been noticed.

Mr. Atkinson said it was a well-known fact that the shales and sandstones between the different beds of coal were thinner in Derbyshire than in Yorkshire. This was shown in a very striking manner by a section of the Derbyshire and Yorkshire coal strata, made by him several years ago, and which was now hung up in the Society's Museum. The coals could be identified, seam by seam, in the two localities; and it would be seen, by reference to this section, that the inter-

stratified measures were in general considerably thicker in Yorkshire than in Derbyshire.

Mr. Lacey—The coal seams all run together into one bed, north of Dudley.

Mr. Hull—Yes.

Mr. Lacey—And they form a bed forty feet thick in one place.

Mr. T. Farrimond read the following paper (illustrated by photography)—

On an Improved Safety-cage for Miners.

Wire ropes have now come into general use, especially in shafts of more than ordinary depth, (say 300 yards), being recommended principally for their lightness as compared with the hempen ropes, the latter being nearly double the weight of the former for the same strength. The rigidity of wire ropes is such that there is great strain laid upon them, and also upon the machinery in overcoming the inertia of the load in starting from the shaft bottom; and should any of the wires be unequally stretched they are almost certain to rupture; for it is a fact, that wire ropes invariably break soon after starting with the load, which is owing entirely to the want of elasticity in the wire; nor are these broken wires easy of detection, the ropes indeed require to be examined with the greatest care and minuteness, owing, in a great measure, to the ingredients used to protect them from oxidation and to reduce friction. To remedy this evil, box-springs are applied to the end of the rope, but those that have been hitherto in use, are so defective, that they retain their elasticity for a very short time. No doubt the box-spring is superseded by those used in connection with the various patent safety-cages, which are now becoming so extensively used, and which must of necessity be kept in working order and re-placed so often as they lose their power to return to the place they were

originally fixed, otherwise the safety apparatus is rendered futile; but, even these springs are far from what could be desired, and there is not the least doubt that if a perfect spring was applied, one-half the proof strength of wire ropes could be worked with as much safety as one-third.

The most effective spring that I am aware of, is one that I have had at work some time at the Bardsley Colliery, in connection with a safety-cage apparatus which I shall shortly have occasion to mention; this spring may be termed a coach spring, which can be applied with facility to any part of the cage, so that one extremity of the spring or its centre is immediately under the rope, or middle of the cage, which is connected by a chain from the rope, which is shorter than those that are attached to the cage; consequently, the centre or short chain lays hold of the spring in the first instance, and brings it to the required position before the drawing chains can take hold of the cage and its load; this spring can be made of any strength, (which of course must be regulated by the weight of the cage) and it will travel a greater distance, and retain its elasticity longer than any other kind of spring, therefore, it is with confidence recommended to all collieries where wire ropes are used.

With regard to safety-cages, the necessity of which is becoming more acknowledged, and their adoption more general throughout the coal-fields of Great Britain, their efficiency depends almost entirely upon the springs by which they are worked; and as these springs are more or less perfect, so, we may conclude will be the safety apparatus itself. If the springs have lost their strength, and cannot compel the rope to travel with greater momentum than the cage, the catches are kept open and the cage falls to the bottom of the shaft. The velocity of the rope, though there is no friction, is greatly impeded by its being brought in contact with the pulley frames, head stocks, horse trees, and conducting rods of the shaft, from which it is evident, that if the springs are not sufficiently powerful to pull the rope to the cage, or if one of the

springs should be stronger than the others, and bring one of the levers against the conducting rod before the others, it is almost certain that the rods are broken and the cage leaves them entirely.

In my improved safety-cage (which I have before alluded to) all the levers must work at once; one cannot move unless they all move, as they are all in connection with one spring, the most perfect yet made. The levers are eccentric, and when in work hang perpendicularly, and four or five inches from the rod, but when brought into action, they travel through an angle of 90 degrees, and strike the conducting rods in a tangent, and bring by degrees a large diameter to bear upon the rods; if they are of wood they embed themselves, if of iron or wire they act as a break, with a certainty that will be at once apparent to anyone who sees them. The spring can be very easily tested by the banksman letting the chains hang loose, and then lifting the centre chain, and, consequently, the spring. The cage can be arrested, when descending the shaft, by the chain being held by a person standing on the top of it; and, when the cage is travelling at the ordinary speed, by letting the chain go, the cage is instantly stopped.

The total weight of the cage,—(drawing 24 cwt. of coal each time,) from which three photographic views have been taken, and are now before you,—does not exceed 8 cwt., which includes the safety catches. The weight of the safety apparatus is half-a-hundred weight; being less than half the weight of any other safety apparatus. This fact is not to be overlooked, nor the adaptability of the apparatus to any kind of drawing tackle for winding minerals to the surface, whether carriages or carriers, and whether the conductors be wire or iron, which are mostly used in our deep upcast shafts. The simplicity of the apparatus too is such that any blacksmith can make it and put it on to any cage or carrier in one day.

On the motion of Mr. Atkinson, seconded by Mr. Knowles, the thanks of the meeting were given to Mr. Farrimond for his paper.

In reply to the President, Mr. Farrimond said he intended to have brought a model, but it was not quite ready.

Mr. Binney—It would be well if gentlemen would deposit their models in our Museum. It would be well also if Mr. Bradbury would furnish a copy of his section to the Museum.

Mr. Bradbury said he should be happy to do so.

Mr. Lacey said the cage described by Mr. Farrimond seemed very like one which had been invented for the Belgian mines by a Frenchman, and of which he had a drawing.

Mr. Farrimond (after looking at the drawing)—The spring is something like it, but that is all.

The President called attention to a recent paper on a similar subject by Mr. Landale, in which it was sought to be shown that the springs were a novelty.

Mr. Binney—I think you answered the matter then, by saying that it might be for Scotland, but would not be for England.

In reply to Mr. A. Knowles, Mr. Farrimond said he had only one spring to his cage, and that the spring of this and the springs of the other safety-cages in use, took off the jerk and saved the winding ropes.

The proceedings terminated with a vote of thanks to the President, proposed by Mr. Binney, and seconded by Mr. J. Taylor, jun.

ERRATA.

Page 262—15 lines from the top; *for* $v^2 = \sqrt{\cdot 0018} = \cdot 042426$, *read* $v = \sqrt{\cdot 0018}$, &c.

Page 290—10 lines from the top; *for* $h = \frac{klv^2}{dg^2}$, *read* $h = \frac{klv^2}{2dg}$

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 14.] [Session 1861-62.

ORDINARY MEETING, *Tuesday, May 27th*, 1862.

JOSEPH DICKINSON, ESQ., F.G.S., President, in the Chair.

THE SOCIETY'S EXCURSION.

Mr. Binney said he would read a short account of the Society's recent excursion, and proceeded to read the following :—

AN ACCOUNT OF THE EXCURSION TO TODMORDEN.

Agreeably to a resolution come to at the last meeting of the Society, the Honorary Secretaries made arrangements for an excursion to the beautiful valley of Todmorden. A party consisting of the President, (Mr. Dickinson,) the Honorary Secretaries, (Messrs. Knowles and Atkinson,) Mr. Hull, of the Geological Survey, Messrs. John Knowles, Kay Knowles, Bennett, Binney, Horsfall, and Hunt, met at the Victoria Station and went by the quarter-past ten, a.m. train to Todmorden. On reaching our destination we were joined by Messrs. Baines and Burgess, of Brighouse, two members of the Geological and Polytechnic Society, of the West Riding, of Yorkshire, the Rev. W. N. Molesworth, M.A., of Rochdale, and Mr. Whitaker, of Burnley, and

proceeded along the valley to Gauxholme where we entered Dulesgate. The whole of the distance from the station to Gauxholme is over strata belonging to the lower portions of the millstone grit. At the entrance of Dulesgate we saw a strong gritstone rock, dipping at a considerable angle to the N.W., which shewed some nice examples of shakes and faults. The exact position of this rock, with regard to the underlying limestone shale, we could not see. In many places the line of demarcation between these beds is not easy to make out, for in the shales are beds of gritstone, and in the latter are beds of shale, so that the boundary is hard to define. At Pendle Hill, beyond Burnley, and at Tintwistle, near Glossop, are two natural sections which can be pretty well measured, especially the latter, where, between the Rhodes Wood Quarry in the valley, and the thick bed of rock of Tintwistle Nar, on the hill, will shew 7 or 800 feet of strata. The whole of the deposits lying between the limestone shale and the upper millstone of the Lancashire geologists, (the Brooksbottom sandstone,) may be taken at 1200 feet in thickness. It is much to be desired that the gentlemen connected with the Geological Survey should accurately measure these beds, which are considerably thicker than have been hitherto supposed, and probably attain their greatest developement in Lancashire, Yorkshire, and Cheshire.

Returning again to the Gauxholme rock, which is no doubt low down in the millstone series, we observed a small seam of coal; and, a little further up the valley, another bed of a few inches, in the roof of which the sharp eyes of Mr. Whitaker discovered an univalve shell of three-quarters of an inch in length, resembling a *Melania*, and which had not hitherto been found by any of our local geologists in that position. From the entrance of the valley to the quarry on the right hand side of the way, worked for road making, and probably the bottom of the Brooksbottom series of coals, which are not well developed here, cannot be less than 1000 feet. Two of these seams have been met with,

and probably the other could be found on diligent search. The Haslingden flags are then seen, but not of great thickness or good quality. Then comes the rough rock, with the Featheredge coal, of 14 to 16 inches in thickness, lying embedded in its upper portion. Above this was the foot coal, the salts, and the Spanish juice seams, which are there, but are not well exposed. We next came to the gannister coal, which is here 5 feet 6 inches in thickness. It contains bullions in the coal, the same as the Spaw Clough, Town Head, and Carry Heyes Mines of Burnley; and nodules, in the black shales of the roof, full of *aviculo-pectens, goniatites, &c.* There is a hard rocky floor of gannister below the under-clay, but it is not one of the best examples of this stone. About 10 yards above is another small seam of a few inches, and then comes the forty-yards coal 20 inches in thickness, with a fire-clay floor, worked for making bricks and tiles; further up is another small seam, and then we saw the upper or Old Lawrence series of flag-stones. To the left of the quarry the strata are thrown up by a fault of fully 100 yards, and the Rochdale coal is wrought by a tunnel through it.

We crossed the moor near the flag quarry and went down the clough to Portsmouth, passing the fine cliffs of rough rock above that place. In the valley, in a cutting of the Burnley railway, is an interesting section of some of the Brooksbottom coal-measures, shewing a small fault. Beyond Messrs. Fielden's Mill, we saw some old workings of the gannister coal, which is there brought in by a fault of 4 to 500 yards in extent. We reached the Inn at Todmorden to dinner at half-past four.

After spending a delightful day, in which we were favoured by fine weather during our walk, we accepted an invitation to visit our Yorkshire friends, in the course of the summer, at Low Moor; and there examine the coals and ironstones from which the celebrated Low Moor iron is made, and which deposits, especially

the coals, are not well developed in Lancashire. By availing themselves of this opportunity our members will have a chance of investigating a part of the carboniferous strata seen there better than anywhere else; and, at the same time, reviving our old acquaintance with the Geological and Polytechnic Society of the West Riding of Yorkshire, a kindred institution to our own, and with which we have been on the most friendly terms for upwards of twenty years. The meetings of the members of different Geological Societies in the field, examining natural sections, and discussing the subject on the spot, cannot but result in advantage to all who attend them.

Mr. John Atkinson produced one or two of the univalves referred to in the above paper, which he said had been presented to the Society by Mr. Joseph Whitaker.—A vote of thanks was given to Mr. Whitaker for the gift.

SAFETY-LAMPS.

The President—I will read you a letter referring to our last month's proceedings:—

May 6th, 1862.

The Secretary of the Manchester Geological Society.

SIR,

On reference to the Mining Journal for last week, I find that at your last monthly meeting a discussion took place on safety-lamps. I more particularly refer to Mr. Binney's remarks. I have enclosed one of the circulars of the largest and oldest lamp-makers in the kingdom. The annexed circular will be a good response to Mr. Binney's remarks, and will, I think, prove to be

the desideratum he and your worthy President refer to. They have doubtless never seen the 'Mozard' as made by J. Abbot & Co.

Any further information will be gladly given.

I am, Sir,
Your obedient Servant,
CHARLES BASS.

THE MOZARD SAFETY LAMP.

The body of the lamp is provided with a male screw, and the frame supporting the upper portion or top has a corresponding female screw. This frame has a cavity to receive a bolt, which is forced into it by a spring, and the top of the bolt having an inclined surface, it follows that *when the Lamp is lighted the top can be screwed on, but cannot return unless the bolt be lowered. The axis which carries the wheel for raising the wick has a projection which, upon the wick being lowered as far as possible, depresses the bolt; this lowering of the bolt cannot, however, take place until the wick is drawn completely within the tube and extinguished.* The lowering of the bolt whilst the wick is alight is effectually prevented by providing that the *wheel for raising the wick* cannot make more than seven-eighths of a revolution. This, if such a wheel be one inch diameter, will allow two-and-a-half inches of wick to be burned before re-trimming the Lamp, and is calculated to burn continuously for eighteen hours. The Lamp has a solid iron chimney in the gauze top, so that it is impossible either to remove the top or to draw the flame through the gauze. The glass is about three inches diameter, and one quarter inch thick, and the supports which carry the upper part of the Lamp would prevent the glass being broken, unless wilfully. The double plate above the gauze keeps the hand ring cool.

MANUFACTURED BY JOHN ABBOT & CO.,
Park Works, Gateshead-on-Tyne.

He sends a drawing of this Mozard's safety-lamp, which is, in reality, a modification of the Museler lamp; but in the description which he gives of it, it appears to be fitted with a self-extinguishing apparatus, in case the lamp should be attempted to be unscrewed; and it has also attached to it a screw and rack for raising or depressing the wick as Mr. Binney suggested should be the

common plan. Now, it appears that some people have supposed, from the remarks which Mr. Binney made on that occasion, that such a proposal had never been made before; but that really is not the case, for, to my own knowledge, Mr. Binney himself has possessed one of these lamps; and it has been tried at collieries, and it has been in my possession for two or three years, and I have made a great many experiments with it. This is it, (producing the lamp,) and it is actually fitted with this screw and rack as Mr. Binney was suggesting. It was not that it was anything new, but it was not so generally adopted in practice as it should be; indeed it was quite the exception to meet with a lamp of this kind. But it is not a new invention; and it was more for the purpose of giving the lamp-makers a hint to adopt improvements, than to lay hold of something new, that Mr. Binney spoke at the last meeting. This (producing another lamp,) is a lamp brought here by Mr. Lancaster, safety-lamp manufacturer, at Nelson, near Burnley; and it is brought here in consequence of what was said at our last meeting. Mr. Lancaster supposed that no such lamp was in existence, and has, I believe, taken preliminary steps for patenting his invention; but it is really no invention, as you see both by this letter I have read from Mr. Bass, and also by this other lamp, which I tell you I have had in my possession for two or three years.

Mr. Binney—This gentleman from Nelson has sent a lamp on the reflector principle. It has glass inside, and is burning a hydro-carbon oil.

Mr. Lancaster—It will also burn vegetable oil and sperm oil.

Mr. Farrimond thought the light would go out with a current of air through the gauze, at the top; and proceeding to blow through the gauze he blew the light out.

The President—Mr. Lancaster brought his lamp to me, and I advised him not to take steps to patent it. I hope he will bring out the lamp in as improved a form as possible, and then it will sell; but it will be no use to patent the argand burner and the screw for raising the wick.

Mr. Lancaster—I don't propose to do that, but I propose to patent the working of the wick by the screw at the bottom.

Mr. Binney—I have never seen the screw at the bottom, but at the side. There is one in the Great Exhibition with a rack at the side.

Mr. J. Atkinson suggested that in order to prevent the lamp being blown out, the top might be made of tin.

The President—Mr. Eloin's lamp is made of brass; but the great objection is, that it gets too hot. Gauze is the best cooling surface we can get as yet.

Mr. J. Atkinson—You might have something in the way of paper or pasteboard, or some other slow conductor of heat.

The President—That would scarcely do.

Mr. Lancaster—Blowing at the top of the lamp is a very exceptional case.

Mr. J. Atkinson—Carrying a lamp in a current might blow it out.

Mr. Lancaster—No.

Mr. Binney—To blow in a lamp is a very severe test.

The President—I think you would blow any lamp out by blowing as Mr. Farrimond did.

Mr. Binney said it was a strong recommendation for a lamp if it went out owing to the air being foul. It would be one of the greatest blessings if safety-lamps would go out as soon as they get into an explosive atmosphere.

The President—That property is presented by the Museler, the Stephenson, and the Mozard, as has been stated at previous meetings. It is aimed at that the gauze should be highly polished. Mr. Cayley's committee on coal-mines recommended white metal, but on exposing the white metal to a flame of gas it melted, and closed the interstices of the gauze.

Mr. Lancaster—I should say copper polished would be cheapest, because it would not corrode.

The President—It is not so strong as iron gauze.

Mr. Lancaster—But it will bear compression better.

Mr. J. Atkinson—You get a better light with Mr. Lancaster's lamp.

Mr. Lancaster—I have had the light burning for twelve hours, and the top has been so that you could carry it about comfortably; and the cost of the oil was only 1½d.

Mr. Binney—No doubt it would be a great saving with these oils.

The President—Mr. Binney, would you recommend the hydro-

carbon oils, the paraffine, and the rock oil of America, to be used in safety-lamps; would it be safe to use such oils?

Mr. Binney—I don't think there would be any more danger in using those oils than in using any other oils.

The President—Do you think if the rock oil, or the paraffine oil were spilt on the gauze, or got heated inside, the gas would be more liable to explode through the lamp than with ordinary oil?

Mr. Binney—The hydro-carbon oil would be just like any other oil, in assisting the flame to pass through a gauze. I could tell you a great deal about it, but being a paraffine oil maker I don't like to say too much.

Mr. J. Atkinson—My experience of it for the three years is, that it is as safe as any other oil, and most economical.

The President—(referring to Mr. Lancaster's lamp)—This lamp seems to burn very well; and if there is any likelihood of safety-lamps being brought into use to burn this paraffine oil, I think it would be very desirable that a committee of this Society should be appointed to test safety-lamps with this oil, to see if it is as safe as the ordinary olive oil, because it would be unwise to put oil into a safety-lamp if it is at all explosive.

Mr. Binney—I think we are obliged to the gentleman for bringing us this lamp. It is nearly four years since the other lamp was brought out, and it was sent amongst the coal proprietors to give their opinion upon it, but no one did so. We are obliged to Mr. Lancaster for bringing us his lamp; which is really a very beautiful lamp, embodying the same principle. Before, however, this lamp can be pronounced desirable, it would be well that we

should have a committee to examine it, and report upon it. It looks, as far as I can see, a very good lamp.

The subject then dropped.

Mr. A. Knowles read the following paper, by Thomas Evans, Esq., Her Majesty's Inspector of Mines for South Wales :—

Description of Water-balance Machines, used for winding Coal, Ironstone, &c., in South Wales.

Along the northern edge of the South Wales coal-field, the outcrop of the coals are, for the most part, exposed to view, and have been worked for many years in conjunction with the argillaceous ironstone, in a similar manner to slate, stone, or other quarries. There is, however, a limit to this mode of excavating, or as it is locally termed "patching" the mines; it can only be done profitably to the extent that will pay for the removal of the top or superincumbent deposit, and the free water drainage.

When shafts had to be sunk it became necessary to devise some means of lifting the materials, the abundant and continuous supply of water running down the hill-sides to the valleys, suggested the employment of "Water-balance Machines;" they have been, and still are extensively used throughout South Wales to considerable depths, and indeed until of late years a steam engine for winding coal from shafts was unknown. These water-balance machines are so placed at different levels that the same water, after being used at the one, flows away by its own gravitation to the next, and so on in many cases to five or six consecutively, and then to the adit level at the lowest free drainage; and in some cases they are used even below the adit level, the pumping engine,

or water-wheel, necessary for the drainage of the mine, is made of sufficient power to pump the water back to the adit or surface as the case may be.

The drawings are those of a water-balance machine, at the Cwm Bargoed Pit of the Dowlais Iron Company.

This is an upcast shaft about 154 yards deep, sunk to the "Upper Four-foot Mine;" so well known in the market as the "Merthyr Steam Coal," working about 300 tons of coal a day, (twelve hours.)

The train containing about 20 cwt. of coal, is placed upon the top of an empty water bucket, at the shaft bottom; and the empty train on the bucket at the top; this bucket upon being filled with water descends, raising the full train of coal and the empty bucket from the bottom. A valve is placed at the bottom of each bucket, and immediately on its arrival at the shaft bottom, the valve is lifted and the water let off. The next full train is then placed on the bucket and treated in the same way.

The buckets are of a circular form, and are made of half-inch boiler-plate iron, and hold about 2 tons of water.

The over or landing chain is three linked three-quarter inch iron, weighing about 48 lbs. per yard; the links are fastened together with wooden blocks; it works over a turned pulley, about 9 feet diameter. A single-linked chain, of the same weight per yard as the landing chain, is attached to the bottom of each bucket for the purpose of balancing the landing chain—this chain hangs loose in the shaft.

The motion of the machine is controlled by a powerful break pressing against the pulley.

The guide chains are long linked, of three-quarter inch iron.

The shaft must necessarily be large to give room for both buckets, it is 18 feet X 10 feet. The weight of the empty train is 10 cwt., and holds about 1 ton of coal; it takes 1 minute 20 seconds to fill the bucket with water and raise the load.

For some time a three-linked chain was used as a balance-weight; it was found, however, in working fast, to raise from the sump a large quantity of water, so much so, as to interfere with the men at the bottom of the shaft; and its use was discontinued. Three-linked chains are unquestionably safer than single-linked, and they should not be condemned, for it is a very easy matter to arrange the sump so that the water might run off as quickly as discharged from the bucket.

The water is pumped from the bottom of the shaft to the surface by means of a Cornish pumping engine; the same is also used for the drainage of the mine. The actual cost is as follows—

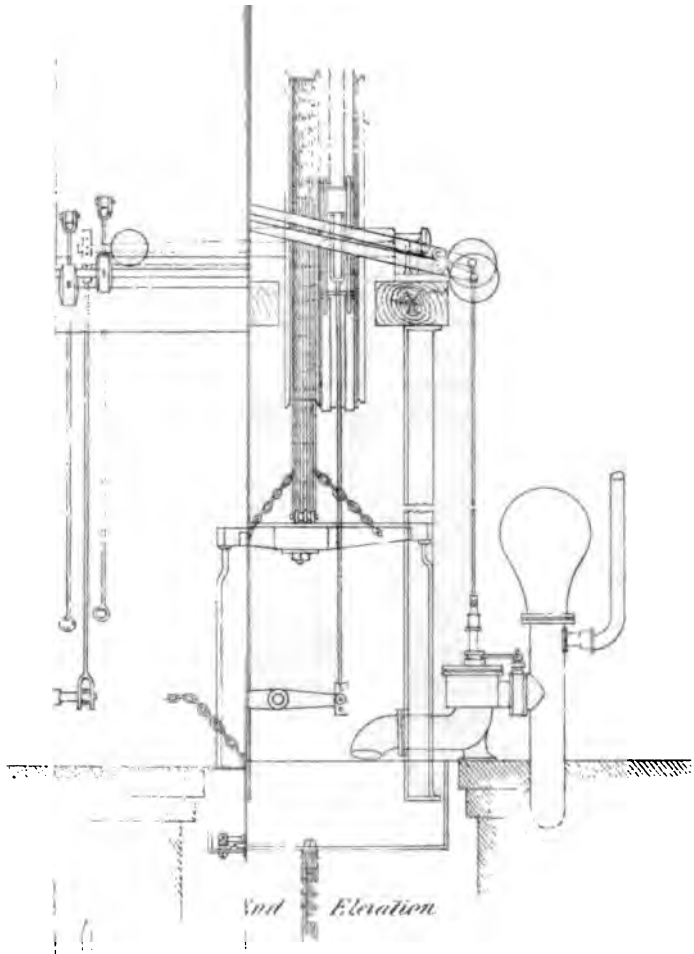
	£	s.	d.
One Breaksman, @ 18s. per week.....	0	18	0
Two Landers, @ 13s. each per week.....	1	6	0
Two Hitchers, @ 15s. each per week.....	1	10	0
Oil for Pulley, ...	0	1	0
	3	15	0

Making 1800 tons per week.

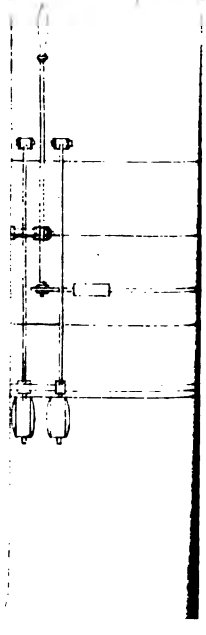
Cost... $\frac{5}{10}$d.

Add to this half the expense of the pumping engine $\frac{4}{10}$d. making nearly 1d. per ton.

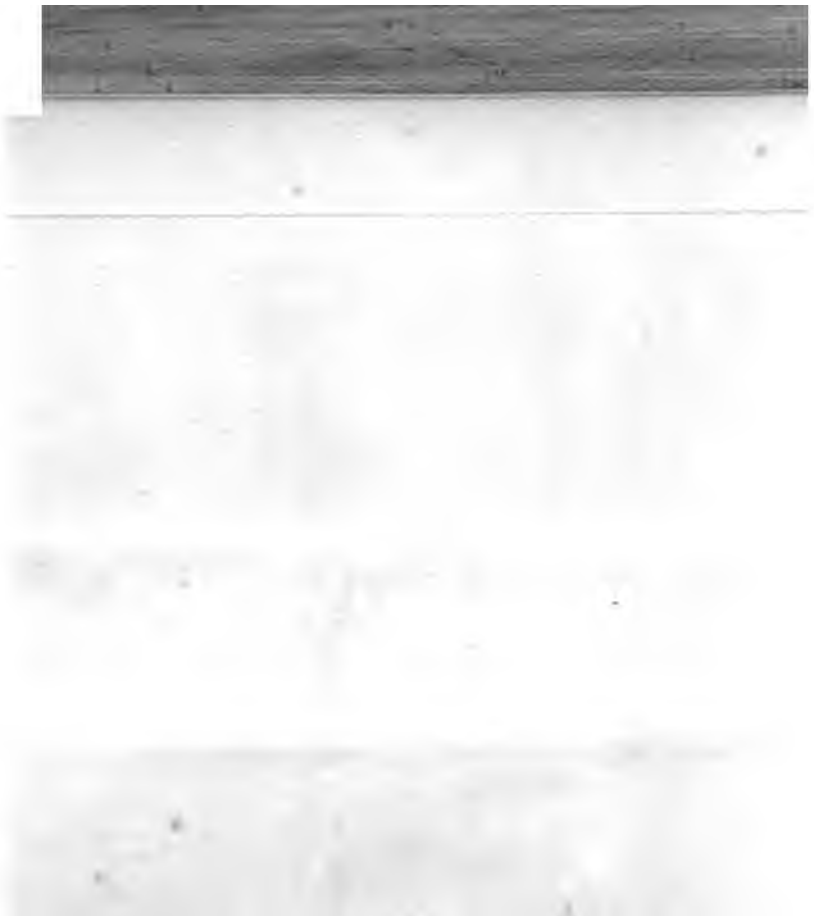
At the Dinas Colliery, the water from the mine, together with that used for working the balance machine, is pumped to the surface by a water-wheel. The shaft is about 90 yards deep, of



End Elevation



PLAN
OF
BALANCE PIT



an oval shape 15 feet x 11 feet. The chain is four-linked, of $\frac{11}{16}$ inch iron. The balance chain is $\frac{1}{12}$ inch iron. Each chain weighing nearly 2 tons.

The bucket is of half-inch boiler-plate iron, and measures 5 feet 8 inches x 4 feet 5 inches x 3 feet, raising about 340 tons in twelve hours. The load of coal averaging 22 cwt. One man and a boy are employed at the bank, and the same at the bottom—the man at the bank has charge of the break, and is also the banksman.

At one of the most extensive works in Wales, all the coal and ironstone are brought to the surface by these machines, (nearly 1000 tons per day,) and one of the shafts is about 190 yards deep.

The cost of erection in the first place is small, and if attention is paid to the quality and manufacture of the iron in the chains, the repairs are very trifling, with the exception of a little oil for the bearing of the pulleys. They require no stores.

For mines not exceeding 180 yards deep with free drainage, and when the amount of work required to be done is not more than 250 tons a day, (or twelve hours,) they are a cheap means of winding coals. The time occupied in filling the bucket with water is the limit to the amount of work that can be accomplished. At greater depths, the machinery becomes so ponderous and heavy as to be attended with inconvenience and danger.

There are in Glamorganshire alone about sixty of these water-balance machines now at work. They are all alike in principle, varying in strength according as the work required to be done, and adapted to the peculiar circumstances which present themselves. The drawings and description of the Dowlais and

Dinas Machines, are, I hope, sufficiently clear to be understood; and if the subject induces useful description, the object of this paper will be attained.*

On the motion of Mr. Binney, seconded by Mr. Atkinson, the thanks of the Society were voted to Mr. Evans for his paper.

Mr. A. Knowles—I have heard there are no water-balance pits in Lancashire.

The President—I think I have seen some at the Hæmatite Mines, at Dalton and Lyndal, in North Lancashire; and also at Cleator, in Cumberland. Then again, there is one at the Blue Ball Colliery, at Bacup, but it is worked somewhat differently; it is worked by a rope which goes over a drum, in the ordinary mode of winding with the steam engine; both ropes go over the drum. Then there is another at Cliviger Colliery, in this county; but they are not numerous, except in South Wales. There were some at Worsley; and it is only a few years since they ceased work there.

Mr. Binney—I have not been there for many years. They were Brindley's.

The President said in South Wales it was found more economical to employ the surplus water than to employ a winding engine.

Mr. Hull said that the power of gravitation was more used in

* See the accompanying lithographed plate.

South Wales than in any other coal-fields in Great Britain, owing to the mountainous character of the district.

The President—The expenes which Mr. Evans gives for pumping the water of the balance pits is only $\frac{2}{5}$d. per ton; which is a small sum, that is, for the depth to which they have already gone.

Mr. Farrimond, being called upon by the President, then explained his

MODEL OF A NEW SAFETY-CAGE FOR MINERS.

He said, the weight of the cage is supported by four chains, but before these chains come to bear weight, the centre chain is stretched, and pulls the springs into a position to bring these levers perpendicular. The levers are attached to the two shafts; and as soon as the rope breaks, of course the centre chain goes slack, and the levers come to and strike the rod at an angle of 90 degrees, and being eccentric the more weight that is brought to bear on them the tighter they hold.

In reply to questions, Mr. Farrimond said that to have teeth in the conducting rods would not be very convenient; and that his invention would act equally well with iron as with wooden conducting rods.

The President—In White & Grant's apparatus I think it was found, that the length of those bars are so great, that when any strain comes upon them, they bend. The apparatus we have working in this country, has the working apparatus close to the bearing surface, which is a great advantage; but in this instance you have it removed as far as possible from the bearing surface.

Mr. Farrimond—In White and Grant's cage, the springs were at the end of the rods, and the power was applied in the middle which twisted them. In mine, the power is applied direct to the spring or bearing surface, and not to the rods as the President supposes.

The President—Supposing these bars get bent?

Mr. Farrimond—They cannot get bent—they have nothing to do but simply turn their own weight. The office of the spring is to pull the rope to the cage, so as to allow the rods to turn round, each on its own axis.

The President—Still all the action is given to these rods from the centre.

Mr. Farrimond—But there is never any strain put on them.

Mr. Hull asked if accidents from the breaking of the rope were not very rare?

Mr. Binney replied that many lives were lost in that way every year.

The President said it was a common rule, that the weight of men in one cage should not much exceed half the dead weight.

Mr. J. Atkinson said accidents through the rope breaking generally happened in a morning, and he supposed the rule which compelled the letting down the cage and bringing it up again before the men were sent down, was not often attended to.

The President said he thought on the contrary that that rule was strictly obeyed; and Mr. A. Knowles concurred.

Mr Binney—It is difficult to speak about ropes. I once saw two heavy women brought up a shaft, and when the empty cages were sent down immediately after, the rope broke.

The President—When there is much swing allowed to the rope between the engine and the pulley, it is surprising what a strain there is put upon it.

Mr. Binney—It is desirable that there should be every care and caution used in letting men down and bringing them up the pit. There cannot be too many contrivances to save life.

Mr. J. Atkinson said Mr. Farrimond's cage seemed well adapted for the purpose for which it was intended.

The President—I can only see the objection I have named.

Mr. Farrimond—And that is no objection in reality.

Mr. Birkenhead said he thought the most important part of a safety-cage was its springs; and if he was not mistaken, many of the largest coal-proprietors objected to safety-cages altogether, because they thought that, in the hour of need, they would be found wanting. It should be remembered, that whilst the safety-cages were in operation and going on well, the springs were generally in a state of tension, and the constant vibration made them rapidly lose their power and elasticity. The springs should therefore be constantly examined.

Mr. J. Atkinson said he thought it might be possible to make the cage so that the springs should only come into use when the rope broke.

Mr. Farrimond—It all depends upon the spring. This cage

has the best spring that has yet been invented. That is the great principle of this cage.

Mr. Birkenhead—The same objection applies to all springs.

The President—The banksman at the top ought to see that the springs are in working order. It may be seen every time the cage rests upon the catches.

Mr. Binney said there was nothing in a mine which required looking after so much as, what were termed, the simplest apparatus. The conversation shortly afterwards dropped.

Mr. Farrimond produced a specimen of Sternbergia, and a rounded piece of white quartz, which had been found in a bed of coal.

The President said that Mr. Farrimond considered these very rare, as they were found in the centre of the Lower Mountain Mine, Dunkenhalgh Park, near Church.

Mr. Farrimond—This is a quartz pebble found there; it is very pure and will scratch glass.

Mr. Binney—We once thought these pebbles very uncommon, and in twenty years I found but two of them; and I once read a paper about them, trying to account for their extraordinary occurrence; but from Dukinfield, Mr. Dickinson and Mr. Ray brought us a barrowful, and they are now in our Museum. The peculiarity of this pebble is that it is white quartz; they are generally of a brown quartz with a little pyrites on the outside. This is the first I have seen in the lower coals. The Four-foot coal at Pendleton and Patricroft, each yielded a stone; and there was one in the Rydgaled, in North Wales. They were polished and vitrified,

and we thought they were meteorites. It is possible the quartz may have been in solution and precipitated. They have all a scored and polished character, and are very strange. The wonder is, how these pebbles came there.

Mr. Hull—In the most out-of-the-way formations there have been boulders discovered. Granite boulders have been discovered in the chalk, which are quite as little to be looked for as a pebble in coal.

Mr. Birkenhead—I think it is generally thought they have been entangled in the roots of trees and floated.

Mr. Binney—You cannot well have floating in a seam of coal. You have in every seam of coal a floor, with rootlets of *stigmaria* in it; there is no evidence of any floating whatever, unless it is in the rough-rock coal. In all the seams of Lancashire, there is as great a degree of quietude of deposition as can well be conceived. If you take a piece of coal-floor and dissolve it in water and examine the particles, you find them most minute, and indicating the greatest state of quietude that you can have, in a deposit from water.

Mr. J. Atkinson—In some parts of the roof you can take off leaf by leaf, like sheets of paper laid one upon another.

Mr. Hull—If the pebble was entangled in the root of the tree, it might be blown by the wind.

Mr. Binney—But all these plants are aquatic plants. In the *stigmaria* you see the root 30 feet long, with radicals radiating 6 feet from it; and of all things you get the least evidence of anything like floating There is no evidence of land plants. Brongniart's opinion is that the whole of the plants forming coal are aquatic plants, and every one who has examined the tissue of

those plants will say so. Some twenty years ago I published a diagram showing what I considered to be something like the formation of coal. I had a stationary area, probably of 15 or 20 feet of water, with plants growing in great profusion, with their tops out of the water; and in the course of a short time, from this luxuriant growth, a large mass of pulpy black matter would be formed; and after accumulating 15 or 20 feet in depth, it went down gradually with all the trees. Generally all the trees remained upright as they went down; but in the case of a seam like the rough rock, a sudden submergence took place, and a strong current came, and many of the plants drifted. With regard to that coal, it is an exception, and you may by chance find a travelled pebble there; but in any of these other coals I should never dream of finding one in the seam itself.

The President—It is rather late to discuss this matter, for it is in itself a subject sufficient to occupy a whole meeting. It is a very interesting subject, though not of great importance; but on going into a mine and examining the coals, one sometimes casts back a thought as to how they were all formed; and I think anyone has a right to do so, and each man's opinion is perhaps as good as another's, seeing there is no received opinion on the subject. My own opinion is that there was vegetation of some sort going on. I think that the vegetation was gradually getting mixed with sand and mud of different descriptions; and that gradually, in the ordinary course of nature, it separated itself by a process of segregation; and vegetable matter became united to vegetable matter, and sand became united to sand, and mud to mud, and so the strata were formed, as may be done on a small scale by mixing such ingredients together, and then applying the galvanic battery for a length of time,—when the mixture becomes divided into layers like the strata.

Mr. Binney—Those are different questions altogether. These are sedimentary deposits.

Mr. Hull—In the case of the chalk with the flints, there is a segregation there; but it has never been shown that there can be any segregation in the case of carbonacious matter and muddy sediment.

The President—I don't know anybody so well able to give us a paper on this subject as Mr. Binney; and we could have it well discussed.

Mr. Binney—If you take twenty-five years to look at it, you will want no extraordinary means to account for it. We have no resorting to electricity, but we simply want beds of sand and clay, and the action of water and vegetation, very nearly as we have it now. We only want natural causes; I don't like to use segregation and separations too much in mechanical deposits of this sort. In coal-measures, you see the particles of the rocks becoming finer or coarser in a beautiful way; and, every now and then, periods of rest, when the plants forming the coal grew—after a time a subsidence took place.

The President—You find the divisions between strata so fine and smooth, and bands without floor earth in the middle of seams of coal, that you can scarcely suppose any period of rest.

Mr. Binney—That the plants forming ordinary coal-seams, and containing *stigmaria* in their floors, grew on the places where they are found, is now an established theory; and, from the nature of the floors, such growth took place during a period of rest.

The President—I think it is clear enough that the plants forming the coal drew their nourishment from the clay below the seams.

The conversation on this subject then ended.

Mr. Binney laid before the members a very valuable collection of fossil fish, &c., from South America, presented to the Society by Mr. Eddowes Bowman.

On the motion of Mr. Binney, seconded by Mr. Bradbury, a vote of thanks was given to Mr. E. Bowman for the gift.

Mr. Jessop said he had a fine collection of fossils found in the coal, but he could not give them to the society as he had prior claims. Mr. Binney said the Manchester Geological Society would yield to no other in its claims. It was centrally situated for Lancashire and Cheshire, and its Museum was free, and open to everybody without charge; and probably its example might induce the other Museums to be opened free. It was explained that Mr. Jessop has claims in Yorkshire.

After a conversation it was decided to hold the June meeting of the Society in the evening, provided the room could be obtained, of which due notice would be given to the members.

Mr. Lancaster again called attention to his safety-lamp, and in reply to the President said he had spilled the paraffine oil in the lamp, and tried to fire the gas in that way but could not.

The President—Well, that is very strong testimony.

The proceedings then terminated.

ERRATUM.

At p. 303, line 14, "common," read "at Common,"—[Common being the name of a place.]

N.B.—The present number completes Vol. III of the Transactions.—The Title Page, Table of Contents, and Index will be ready for delivery in a short time.

are living out of town, and a great many people go out of town after business hours. At the meetings in the winter it would often be more convenient to attend in the evening than in summer. However, we have made a beginning, and it will rest with the members to say how they will divide the meetings next year—whether they will have them all in the middle of the day to suit the convenience of the country members, or in the evening to suit the town people; or probably we might have a mutual

arrangement, whereby the meetings might be held partly in the day time and partly in the evening. One thing is certain, that the meetings in the middle of the day have been better attended than they were formerly when they were held at night.

Presentations to the Society.

The Chairman—Since the last meeting, John Evans, Esq., F.S.A., F.G.S., has presented to the Society his work, entitled "Further Discoveries of Flint Instruments in the Drift." Edward Hull, Esq., B.A., F.G.S., presented to the Society a Map of the Government Geological Survey of the district around Manchester. The map is on a scale of six inches to the mile. Mr. Atkinson moved, and Mr. Taylor seconded, a vote of thanks to Mr. Evans and Mr. Hull for their respective donations. The resolution was carried unanimously.

Marine Fossils at Dukinfield.

Mr. Hull then, on the invitation of the chairman, gave a short account of marine fossil shells at Dukinfield. He said, I and my colleague, Mr. Green, were perfectly astounded by a discovery we made a short time ago in the coal strata of this district. After tracing up the lower coals from the Gannister series containing marine shells, at Staleybridge, along the river to the Dukinfield collieries, we seemed to be getting to the very upper part of the coal-measures. We found on the bank of the river, near the canal and railway bridge, large nodular masses of semi-calcareous grit, embedded in shale, and cropping out in places. My friend and colleague, Mr. Green, was a little ahead of me. I had clambered down to the bank, and was picking at these nodules, when he called out "Here are *goniatites*," and there they were as large as life, with several shells, the *aviculopecten papyraceus*, and others, which have always hitherto been considered to be confined to the lower coal-measures, and to the series of strata below the Arley mine. We set to work on the spot, and got out some specimens,

which have since been sent to Mr. Salter, who says they are shells belonging to the same genera as those which are found in the lower coal-measures. It is the first time that shells of these genera have been found in the upper part of the coal-measures. Although it is true these coal-strata have never been pierced so as to prove the exact superposition of the shale in which these fossils occur, yet judging from their apparent position with reference to the great coal series of Dukinfield and Ashton, there can be no question whatever that they belong to the upper part of the coal-measures. No doubt there is a little fault running at the back of these beds, but it would require a fault of perhaps 4,000 or 5,000 feet to bring up the lower coal-measures into that position, and there is no fault of anything like that extent in the neighbourhood. Therefore we felt perfectly sure that these shales and the embedded fossils belong to the top of the middle part of the coal series, lying, of course, below all the Ardwick limestone series, and above all the thick coal-seams. The shells belong to the genera *discites*, *orthoceras*, *aviculopecten*, and some others.

Mr. Taylor said that there was no possibility of a fault in that neighbourhood to the extent Mr. Hull had mentioned. The largest fault there could not be more than 200 yards.

The Chairman said there certainly was a possibility that two or three faults might be between Clayton and the point where the fossils occurred, and there might be another on the rise. The district was a sort of *terra incognita*, which no one had at present much explored, and therefore he was not yet thoroughly satisfied. At the same time, the general dip of the strata in which the fossils were found and the middle coal-field of Dukinfield were similar. Whatever the exact position of the strata, the fossils were very interesting, and furnished another proof that the coal-measures had been deposited in salt water. He had visited the locality several times, and collected the *aviculopecten papyraceus*, a rather

small variety, three species of *orthoceras*, one or two species of *nautilus*, or *goniatites*, a *mytilus*, and other shells, as well as some remains of fishes.

Mr. J. Atkinson, F.G.S., one of the Honorary Secretaries of the Society, then took the chair during the delivery of an address by Mr. E. W. Binney on the

Geology of Manchester and its Neighbourhood.

Mr. Binney said—I have had no time to prepare a paper, and have only brought a few maps and sections, and propose to have a conversation on some points connected with the geology of Manchester and its immediate neighbourhood. Most of the facts I shall have to bring under your notice were given by me fifteen years ago in a paper printed in the eighth volume of the Memoirs of the Manchester Literary and Philosophical Society. The commencement of the subject will not be very interesting, being merely an account of the sand, clay, and gravel found in and about the city. Accumulations of this kind are generally known by geologists under the name of "drift." In the term drift there is no theoretical implication. Geologists do not mean to say that these accumulations were formed altogether by drifting in water; but the term is used simply to distinguish the deposits without implying any theory as to how they were formed at all.

On the surface of the land around Manchester we find nothing else but drift, taking the whole country together, excepting in valleys, where the rivers have cut through the drift. In the valley of the Irwell, below Kersall Moor, there are some points where the

bed of the river cuts into some of the trias rocks. Also in the city, by the Cathedral; and up the valley of the Irk, there are trias, permian, and coal-measures. The first and the last named strata are also exposed in the valley of the Medlock. It may, however, be said generally that the whole of the surface of Manchester is covered with drift. This drift is divided into two classes—the valley drift and the general or higher drift. The valley drift is the most recent; and the following table shows the various beds in the descending order, with their thicknesses:—

The drift in and about Manchester may be conveniently divided into the following deposits, in the descending order;—

CHARACTER OF DEPOSIT.	THICKNESS.	LOCALITIES.
VALLEY GRAVEL.		
1.—A bed of coarse gravel, composed of various sized Azoic, Palæozoic, and a few Triassic rocks, well rounded, parted with layers of fine sand, without pebbles, exhibiting every appearance of having been deposited by water; most frequently stratified, but sometimes unstratified. It has generally two well marked terraces above the waters of the present rivers, as well as some minor terraces. On the top of this is generally found about 3 or 4 feet of silty loam.	0 to 12 yds.	In the valley of the Irwell, Lower Broughton, and generally, more or less, in the beds, and on the sides of the three great valleys near Manchester.
FORREST SAND & GRAVEL.		
2.—A deposit of sharp forest sand, parted with layers of gravel of same rocks as No. 1, and having every appearance of a regular deposit by water, distinguishable only from No. 1 by its being found at greater elevations, containing more sand, and being generally more regularly stratified. It sometimes contains thin beds of Till lying in it, and much drifted coal.	0 to 25 yds.	Irlam's-o'-th-Height, Pendleton, Kersall Moor, Higher Broughton, Prestwich, Cheetham Hill, Harpurhey, Crumpsall.

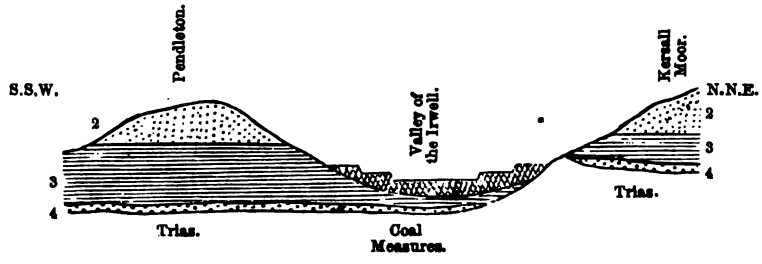
CHARACTER OF DEPOSIT.	THICKNESS.	LOCALITIES.
Till.		
3.—"Till,"* a mass of strong brown clay, in which are mingled the same kinds of rocks as those in Nos. 1 and 2, of sizes from six tons in weight to small pebbles, some rounded and partly rounded, and others quite angular, especially coal-measure and magnesian limestone rocks, without any order of deposition, great and small stones being mixed together indiscriminately, quite impervious to water, and well known as valuable brick clay, and from its being the deposit which yields *striated* or *scored* stones. Several beds of fine laminated silt and patches of sand are found in it.	0 to 30 yds.	The brick-clay of Manchester, Salford, Strangeways, Cheetham, Beswick, Bradford, Ardwick, Openshaw and Longsight.
Lower Gravel.		
4.—A bed of sand, or coarse gravel, having the pebbles (consisting of the same kinds of rocks as Nos. 1, 2, and 3), well rounded sometimes, but not always, occurring under the brick clay, often stratified, and at other times unstratified. It affords good springs of bright water.	0 to 11 yds. but seldom above 2 or 3 yards	In the valley of the Irwell, at Pendleton colliery, Cheetham-street, George's Road, Beswick, Victoria Park, and under the Till in the higher part of King-street and Spring Gardens.

Probably the deposits mentioned above will not always be found in the perfect order there laid down; no doubt some of them may be wanting at places, especially Nos. 4 and 2, which have often been removed.

The higher sand and gravel in most parts of the town have been swept away; and then the till or brick clay is exposed. This is especially the case in what may be called the rising ground forming the shoulders of the town. The lower gravel and sand in some places—Chat Moss for instance—is eleven yards thick.

* In and under the city there appears to be but one bed of Till, but in the surrounding country there are two or more beds, parted by sands and gravels.

The valley gravel may be taken to be about 12 yards thick, and probably throughout Manchester this would be found to be correct to within a few yards at most. I have laid it and the other beds down for the use of the Society in Johnson's map of the parish of Manchester, and now exhibited,—the valley gravel being of a greenish tint. It is found on approaching Manchester by the valley of the Irwell, from Agecroft, through Salford, and the lower part of Manchester, along by the New Bailey; and it opens out into Hulme, and extends all the way down to Stretford, with the exception of a piece of till near to the Botanic Gardens. It is also seen in the valleys of the Irk and Medlock, and in the valley of the Mersey, all the way from Marple to Stockport. Here is a rough



section,* which shews the position of the drift in the valley of the Irwell, taken from near Eccles New Road, along the upper part of Pendleton, by the Bolton road, down by the old colliery to Kersall Moor. The valley gravel skirting the hill sides is rather thick. At the Pendleton colliery there is a very good section of it. This valley gravel appears always much higher at the edges of the valley, skirting them all the way till you get into Ford Lane, just above Mr. Higson's house. The highest terrace in the valley, below Barr Hill being about 86 feet above the waters of the present river. There is another terrace near to Pendleton Colliery, about 40 feet above the river Irwell. No doubt the waters once flowing in the valley

* The figures denote the beds mentioned in the table of drift deposits previously given,—p p. 351, 352.

had in former times filled up nearly the whole space between the terraces, and deposited those gravels.

The kind of gravel found here is somewhat similar to that found in the north of France, where it is yielding flint implements, as described by Mr. Evans in his book. Many things have here been found in these gravels, but they have always been considered as of doubtful origin. Some of the old beds of the course of the present river Irwell have been dug out, but little attention has been given to collecting anything from them. It is to be wished that gentlemen would direct their attention to the lowest terrace beds, with a view of ascertaining whether they contain any flint implements, or fossil remains. At one of our meetings a short time ago Mr. Barr stated that he had found a marine shell *(cardium edule)* in the gravel in the neighbourhood of Stockport. On the top of the gravel is a bed of silt, three or four feet thick, and this seems to have been derived from floods, when the river overflowed its banks, and deposited the silt. In the upper terrace there are very often found thin beds of peat, and beds of silt between. These no doubt arose from the water from the sand being stopped in its descent by the beds of till, and caused to ooze out at the lowest level, thus forming the series of springs which supplied most of the old bleach and dye works near Manchester.

On excavating the ground at Brindle Heath, Pendleton, a short time ago, the following was the descending order in which the beds occurred:—

	Ft.	In.
1. Brownish clay	3	6
2. Peat	2	0
3. Blue silt	1	0
4. Peat, about	2	0
5. Silt	0	6
6. Gravel (Valley)	6	0

This is a series of beds which I have not seen anywhere before. I have not found any animal remains there; but the fact is worthy of record, as it will serve to show that there are deposits in or upon the valley gravel, which have not hitherto been noticed. I observed another section lately made in Lockett-street, Strangeways. In the cutting of a sewer down to 20 feet—about the level of the river—the workmen there cut through beds of gravel, sand, and silt, and a large oak tree that lay at the bottom of the sewer, by which the operations were a good deal inconvenienced. At the Gaythorn Gas Works, some years since, after cutting through sand, silt, and valley gravel, the workmen found large oak trees at the bottom of this gravel, one of which was four or five feet in diameter.

The great body of this gravel, at present about the level of the waters of the Irwell, has been moved about in the valley as the river has changed its course from time to time. A singular curve of the river occurs below Kersall Moor, near the Manchester race-course, which shows that the river may have gone straight across from Douglas mill to the place where the present suspension bridge is erected a few hundred years ago, for the river on the Salford side is now encroaching on the Broughton side, and the Broughton side is encroaching on that of Salford at other points. From some of the old plans connected with the Broughton estate it is more than probable that evidence might be got as to what was really the course of the river 200 or 300 years ago, and thus shew the rate of change of the river course per year. Several acres of Salford are found on the Kersall side, and about the same quantity of Kersall on the Salford side of the river, clearly proving that there has been some singular changes since maps were made; for the river was doubtless once the boundary line of the two townships. The waters in the valley there have no doubt been of much greater volume than they are at present, or they

could not have removed the materials from the spaces between the terraces.

Having thus glanced at the valley sand and gravel, I will just say a few words about the upper sand and gravel, which is put down on the table as being 45 yards thick. Taken about Kersall, and in the neighbourhood of the high lands, about Harpurhey, Broughton, and Pendleton, it is moderately simple. It is composed of beds of sand, with a few beds of gravel intermixed, and rests on the till. On approaching Rochdale, Ashton, or even Failsworth and Droylsden, this deposit of sand is not so simple, but sometimes it has two or three beds of clay and gravel in it.

For the purpose of shewing the variation of drift deposits much nearer Manchester than the above-named places, the following section, found in sinking a well at the new Manchester Workhouse, in Crumpsall, is given :—

	Ft.	In.
Clay containing pebbles (an upper bed of till) and sand	21	0
Quick sand	26	0
Loam	4	0
Clay	30	0
Clay in laminæ	5	0
Clay with stones	4	0
Hard clay	0	6
Sand	2	0
Gravel	7	6
Clay	25	0
Sand with small stones		
Red sandstone, (Trias)		

The upper sand and gravel which I have represented as 45 yards thick, contains several deposits of till, as may be seen at Kersall Moor and the higher parts of Broughton. In this neighbourhood I have never found any fossil remains at all in these upper

sands and gravels,* but I have met with fossils at Bowdon, Haigh, Tyldesley, and many other places; and Mr. Taylor has lately discovered some near Stockport.

In this upper bed of sand and gravel it is sometimes found that the top of the knolls are covered in by a bed of clay, occasionally containing pebbles, such as can hardly be distinguished from the lower bed of till itself. In some cases they consist of isolated patches of clay in the sand, and appear as if they had been dropped from an iceberg.

The brick clay, which is known to geologists by the term "till," is the third in the series in the section. In Manchester it has been proved to be about 30 yards thick. It is here put down at 28 yards. This bed of clay contains fragments and boulders from azoic and palæozoic rocks of nearly all kinds, with a few secondary rocks. The table here exhibited will give a fair average per centage of the boulders, &c. derived from different kinds of rocks existing when the clay or "till" now containing them was deposited in its present position. The stones enumerated in the construction of this table were from that part of Cheetham where it is proposed to erect a new county gaol, from a brick yard near Openshaw, and from one in Regent Road, Salford, thus affording a fair representation of the clay deposits in the neighbourhood of Manchester.

Any gentleman may satisfy himself respecting the general correctness of the following table by getting specimens from the brick yards, and counting for himself. There is no danger of the specimens being exhausted; all the brick yards yield them about equally. Sometimes very nice fossils are found in the rocks.

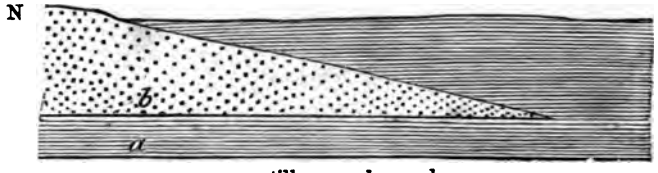
* Since this paper was read, in company with Mr. Prestwich, F.R.S., I have seen small fragments of shells in the sand and gravel found in the new street out of Singleton Brook Road.

TABLE OF ROCKS FROM THE TILL, NEAR MANCHESTER.

Nature of Rock.	Regent Road, Salford.		Cheetham.		Openshaw.		Mean.	
	Per Cent.		Per Cent.		Per Cent.			
Granites, Greenstones, and other Igneous Rocks—		21		15		27		21
Angular	3		5		7		5	
Partly Rounded	12		7		11		10	
Rounded	6		3		9		6	
Slates and Silurian Rocks—		19		27		17		21
Augular	3		4		4		3·66	
Partly Rounded	11		8		8		9	
Rounded	5		15		5		8·33	
Mountain Limestone—		5		6		7		6
Angular	1		2		0		1	
Partly Rounded	3		2		4		3	
Rounded	1		2		3		2	
Coal Measure Rocks—		49		50		49		49·33
Augular	22		31		23		25·33	
Partly Rounded	21		16		20		19	
Rounded	6		3		6		5	
Permian and Trias—		6		2		0		2·66
Angular	4		2		0		2	
Partly Rounded	2		0		0		0·66	
Rounded	0		0		0		0	
		100		100		100		100
Striated Rocks		2		2		1		1·66

In the neighbourhood of Tib Lane—not far from where we are now—about the site of the Savings Bank, the bed of clay is parted with quicksand, and the till seems gradually to go out and the quicksand to come in. This quicksand is found in several parts of Manchester. A singular fact in regard to the junction of the sand and the till sometimes presents itself, and one about which, when I first observed it, I was sceptical as to the correctness of my observation. But there is no doubt of its existence, as I have seen it distinctly in three different places. The fact referred to is the wedge-like manner in which the sand sometimes enters

the till at the junction of the two. The accompanying sketch will show the curious phenomenon referred to, and render a lengthened description unnecessary.



a..till,.....*b*..sand.

This peculiar arrangement of the sand and till has sometimes caused great difficulty to the workmen employed in making sewers. In making a sewer on the Cheetham Hill Road, near Temple-street, such a difficulty occurred, and made sad work with the contractor. The work was abandoned once, and it was thought that it could never be accomplished at all. This fact has never been noticed in any papers I have seen relating to these beds of drift.

The next and last bed of drift is the lower sand and gravel. This formation is not much seen in the neighbourhood of Manchester. It is only in sinking wells and boring holes that it is occasionally met with. A little of it was seen on the railway near the Victoria station when they were cutting it. This is a very interesting deposit. It would be desirable to know what sort of fossils, if any, are to be found in it. The bed has been sometimes found to be about 10 or 11 yards thick. Under favourable circumstances fossils might probably be found in it. I have not had an opportunity of minutely examining it, it is so seldom exposed; but any gentleman would do great service to the geology of the district by carefully examining it. In all the wells in the neighbourhood where we are now assembled, and all the way from Spring Gardens and George-street to Piccadilly, after going

through a bed of till, the sinkers came to about two or three yards of gravel, resting upon trias. This gravel yields a very bright lime water, which is known as "brandy-and-water water," and is much used at the hotels. The pumps in Spring Gardens, Fountain-street, &c. are celebrated for this water.

Having said so much about the drift, I will refer very briefly to the secondary beds found in the neighbourhood of Manchester. These secondary beds consist of trias rock. On the present occasion it would not be necessary to divide the trias into the minute divisions which my friend Mr. Hull has done. In some parts of the town it is from 200 to 300 yards thick. Whether the "lower mottled sandstone" was under this in some places has not yet been clearly ascertained, but I take the Manchester deposits as Mr. Hull's "pebble beds." In a cutting near All Saints' church, Cavendish Square, there is found a bed of red marl, which I once thought was the higher portion of the upper red marl, but I now consider that it is only one of the beds which lie in some parts of the trias. It has some strange contorted bodies in it, but it is not probable that they are of organic origin. Something like 25 years have elapsed since I saw this bed, but I remember observing a layer of something like Fuller's earth in it. This marl was in the upper part of the pebble beds, and was at least 12 feet thick. At Hampson and Pegg's weir, Clayton Bridge, there is a bed of red marls, occupying probably a similar position. No more needs now be said about these red beds; but if any gentleman should have a chance of seeing an excavation between the end of Chester-street, Oxford Road, and Cavendish Square, most probably they would come to light again. However, before leaving the trias it might be as well just to name a section at Mr. Worrall's works, at Ordsall. The workmen there went low down in search of water. The bore appeared to be all in the trias, but at 200 yards they came to a very strong brine spring. This I mention as being the only occasion on which I have ever heard of

salt water having been met with in any of the numerous borings in the neighbourhood of Manchester.

The next formation claiming our attention is the upper part of the palæozoic, consisting of permian and upper coal-measure strata, one of the best sections of which in the district is that of Medlock Vale, exposed by Mr. Wood, who has devoted great energy to the search for coal; and though he has not been so successful as he deserves to have been in his main object, he has succeeded in obtaining much valuable geological information. Near Medlock Bridge he found drift 7 yards 2 feet, trias 11 yards, marls containing limestones, and five or six beds of gypsum, 82 yards 3 inches resting upon red sandstone; and, after getting 140 yards, he came to coal-measures.

Mr. Binney then referred to a difference of opinion between Mr. Hull and himself in regard to the extent and character of some of the faults in the coal-field, and on the direction of the Great Collyhurst Fault, in this district. He said the late Mr. John Bradbury, a sound practical man, who penetrated the whole of the valley from Manchester to Droylsden, having bored every 300 or 400 yards, and also thoroughly explored the Great Fault at Clayton, assured him that the side of the last-named fault looked like a sloping bank, with pieces of rounded coal and rounded stone lying upon it. His opinion was that the edge of the fault in that locality might have been an old sloping cliff, and had long been exposed to air and water. He mentioned this as some gentlemen seem to think that these faults are not sloping at all, but straight. The evidence of Mr. Bradbury was valuable, and his opinion was probably better than that of any other man with regard to that fault.

Beyond Clayton collieries, and towards Ashton-under-Lyne, the strata are called red-measures. The water-works people

have sunk into this formation at Gorton; but very little is known of it till we came up to Dukinfield. The exact boundary of the coal-measures is not very well ascertained; but it is a well-known fact that red clays and also red sandstone have been met with by borers as far east as Failsworth. From Failsworth to Giant's seat, near Ringley, I have sketched out the probable course of permian beds; but I have not met with any fossils in the Giant's seat beds. We are all anxious for any information which can be given as to the geology of the district lying between Middleton and Manchester, and also between Radcliffe and Manchester. There is room for any geologist to invent hypotheses, and to bring as many facts as he possibly can to verify them. The whole surface is covered with drift near 200 feet thick in some places; and after we had got through that there would be a difficulty in telling to what part of the strata we had reached. Mr. Stott has found the four-feet coal at Outwood, near Prestwich, and probably other coals. I do not know that I have anything more to add. I have tried to explain the subject by the two maps, one of the drift, and the other of the older strata, and a number of sections. They are, it is true, very incomplete geological maps for a great city like Manchester, but they contain all the information that has been got after the 25 years work that I have devoted to the district. It is not much to have attained; but we must bear in mind the obstacles which oppose our attempts to obtain correct information,—the great dislocations, and the immense coverings of drift,—and await patiently the further evidence to be afforded from time to time by boring, sinking, and other mining operations.

On the motion of Mr. Taylor, seconded by Mr. Hull, a vote of thanks was passed to Mr. Binney for his very interesting dissertation.

The Chairman (Mr. Atkinson) remarked that there could not be two opinions on the subject, that the address they had heard was very interesting to any one who had not the least knowledge of geology, and still more so to those who had a good knowledge of that science. (Applause.) Mr. A. added that one question had occurred to him while Mr. Binney was speaking of the drift. Was it supposed that these valley gravels were fresh water gravels?

Mr. Binney—No fossils have been found in them, excepting that Mr. Barr had told us recently that he had on one occasion found part of a cockle.

Mr. Atkinson said it had occurred to him that this valley gravel was really marine gravel, and that there had been a communication with the sea up the valleys of the Mersey and Irwell. Manchester, he added, was very few feet above the level of the sea; and the tide came even now to Warrington.

Mr. Binney—Most of the points even of the valley gravel are about 100 feet above the level of the sea.

Mr. Atkinson said he thought from the appearance of the surface, all the country from Warrington, up by Lymm, Broadheath, Sale, Stretford, and to Manchester, had at no very remote period been covered by the sea; and the Manchester race-course seemed to him to have been a bay of an ancient shallow sea. He thought that the till and the upper sand and gravel had been scooped out and washed away by tidal action. There was a possibility that at times, particularly when a change of level from a subsidence of the land occurred, the valley gravel was laid in by a fresh influx of the sea. The upper sand and gravel was continuous, and the till was deposited pretty regularly, as if laid down on the edges and surface of the older rocks, when they formed the bottom of a large gulf. If that view was correct, it was desirable to try to

find fossils or broken shells, such as Mr. Taylor lately gave them an interesting account of, with the view of settling the question as to the marine or fresh water origin of these sands and gravels.

Mr. Taylor—One difficulty in reference to the valley gravel is that the fragments of shells, if there were any, have got worn away with having been deposited along with a rough material, and thus have become broken and shattered, so that they cannot be determined.

Mr. Hull said that he begged to dissent from the opinion that these valley gravels were of marine origin. He formerly entertained the opinion that they were, but there was one reason which he could advance which appeared to him to be decisive that they were old river terraces, and that was the fact that the slope of their upper surfaces coincides with the present slope of the river. If the valley gravels were old sea or marine gravels they would necessarily be very nearly horizontal, and at any rate the change in the level of the upper surface would necessarily be very slight, because in order that the sea should ascend to such a height as 160 feet above the present level, it would require a general submergence of land. Mr. Hull then pointed out, on the map, the difference between his account of the great fault in the neighbourhood of Collyhurst, and that of Mr. Binney.

Mr. Plant said he could corroborate the views of Mr. Hull relative to the fresh water character of the upper gravel, from excavations made when sinking for the foundations of the Museum in Peel Park.

Mr. Atkinson said it would be an interesting point to ascertain what rocks the gravel was derived from.

Mr. Binney said there was every reason to believe that the valley gravel had been derived from the till; and upper sand and gravel, by the action of water.

Mr. Atkinson—There was one difficulty with regard to the question of river or sea deposits. If a river had made those deposits, it must have been an immense river; and where were we to look for the land that would supply a river of such immense volume?

Mr. Hull said that the river would be constantly working from one bank to the other, and very likely the terraces had something to do with the rising of the land.

Mr. Atkinson said that there was a great deal to be done in this district with regard to the gravel and the till. Through the whole of the western district, from Blackpool and Southport to Manchester, and from Liverpool up the valley of the Mersey, there was a very interesting district to be worked out. It was, of course, the most recent period of geology; and very little had been done to it in any locality.

Mr. Hull said no one had a better opportunity of working the subject out than Mr. Atkinson.

Mr. Atkinson replied that unfortunately for the progress of such an inquiry, he had something else to do, or he should be glad to undertake the duty. There was no doubt that there had been a vast expanse of water from Liverpool to Manchester. The valley of the Mersey would well repay investigation.

The meeting then separated.

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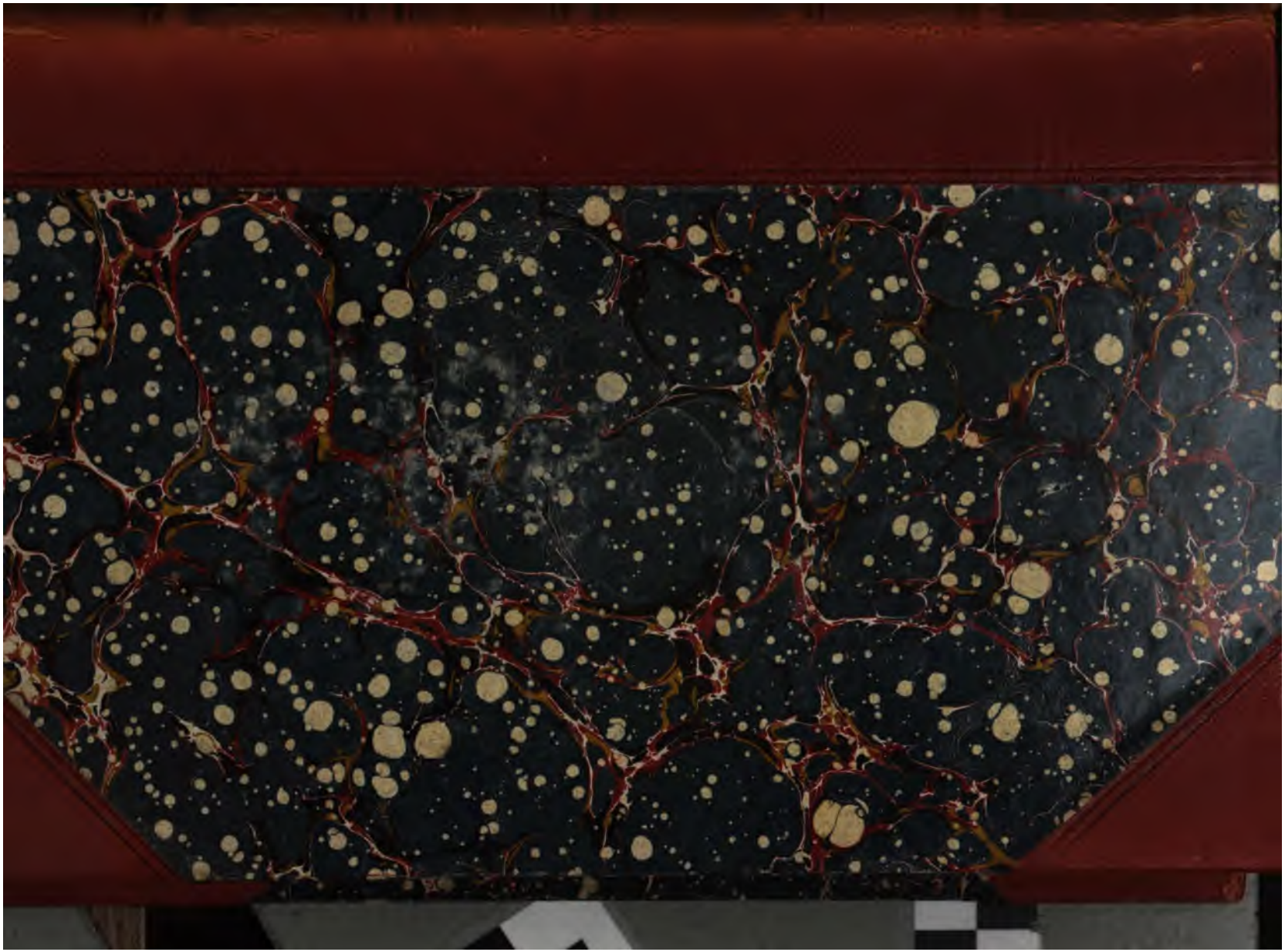
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